Fetal Heart Dopplers by Carol Moser Dungan

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Sites Evaluated & Information Learned

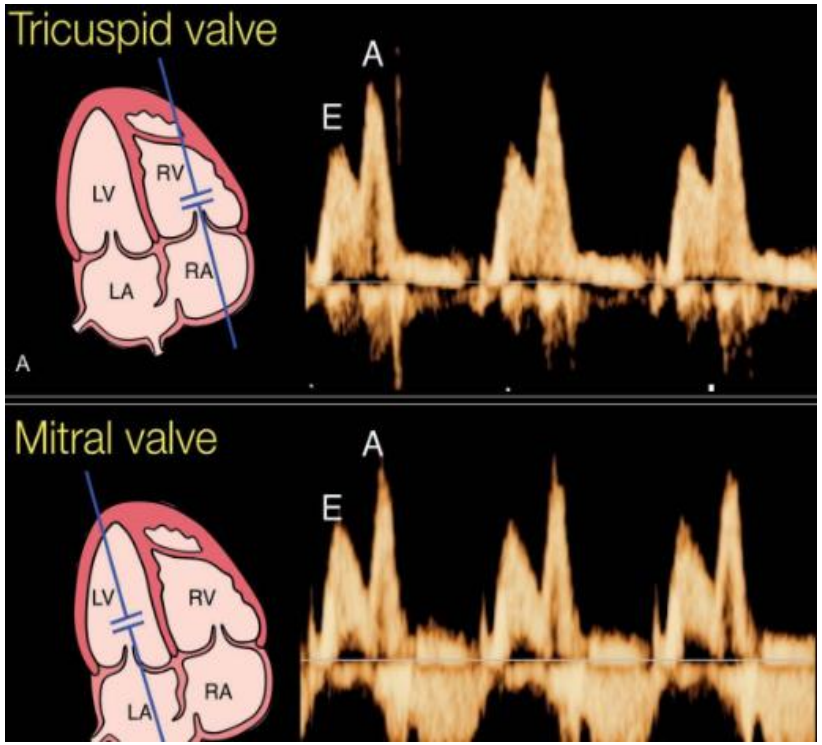
Atrioventricular Valves, (Ventricular Inflow), Ventricular Outflow
Pulmonary Veins, Pulmonary Arteries
Ductus Arteriosus
Aortic Isthmus
SVC
Hepatic Veins and Inferior Vena Cava
PFO

Ductus Venosus
Umbilical Vein and Umbilical Artery
Middle Cerebral Artery

AV Valves- Mitral and Tricuspid Valves

Normal:

Biphasic E/A flow



Optimizing Doppler angle:

Ideally should be zero

Smallest angel possible

Place sample volume at brightest color flow area

Keep sample volume small for small areas

Do not use angle >60

No flow at 90 degrees

Lower frequency probe sometimes helpful

Color scale around 70m/sec

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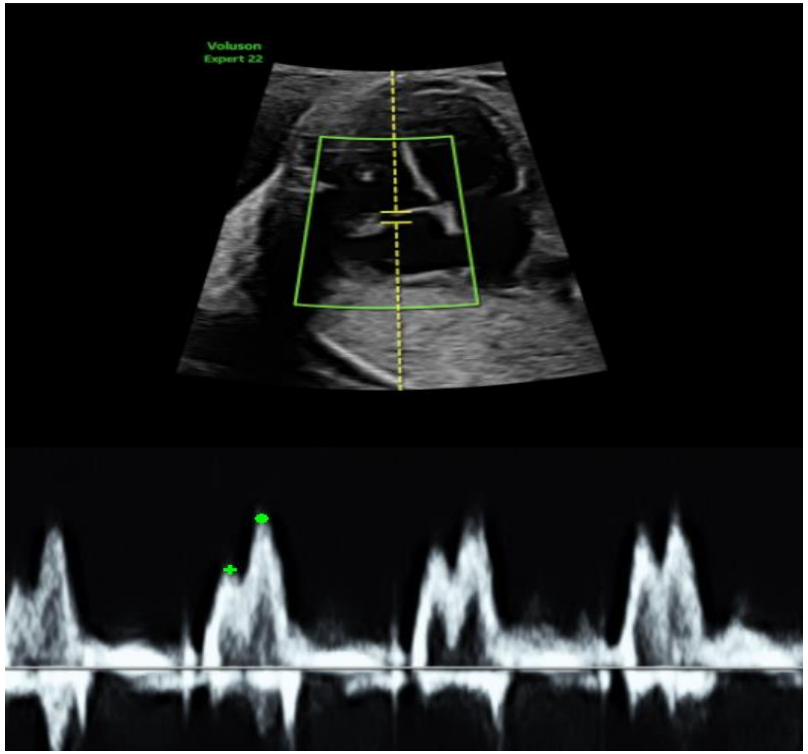
AV Valve: Mitral and Tricuspid

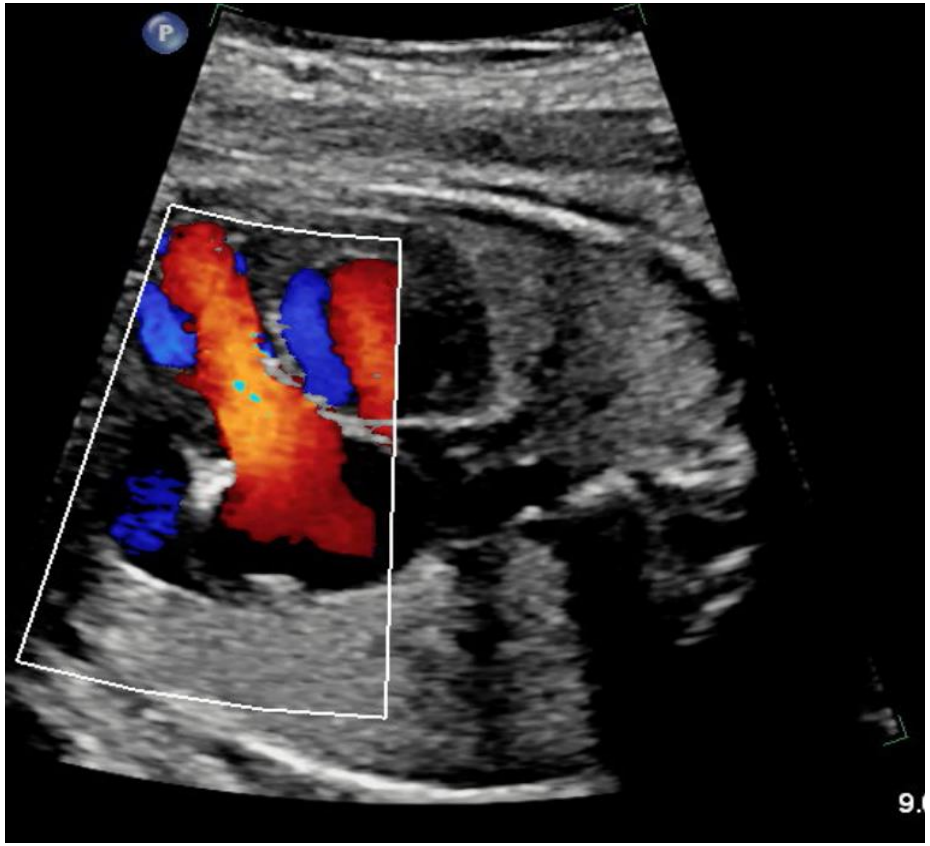


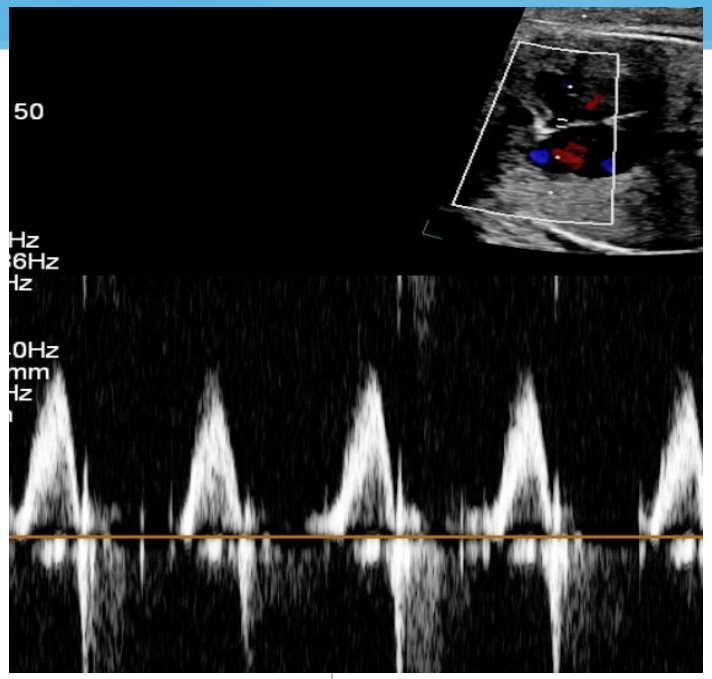
Normal MV/TV flow is biphasic, E wave is usually lower than A wave and increases with the gestational age.

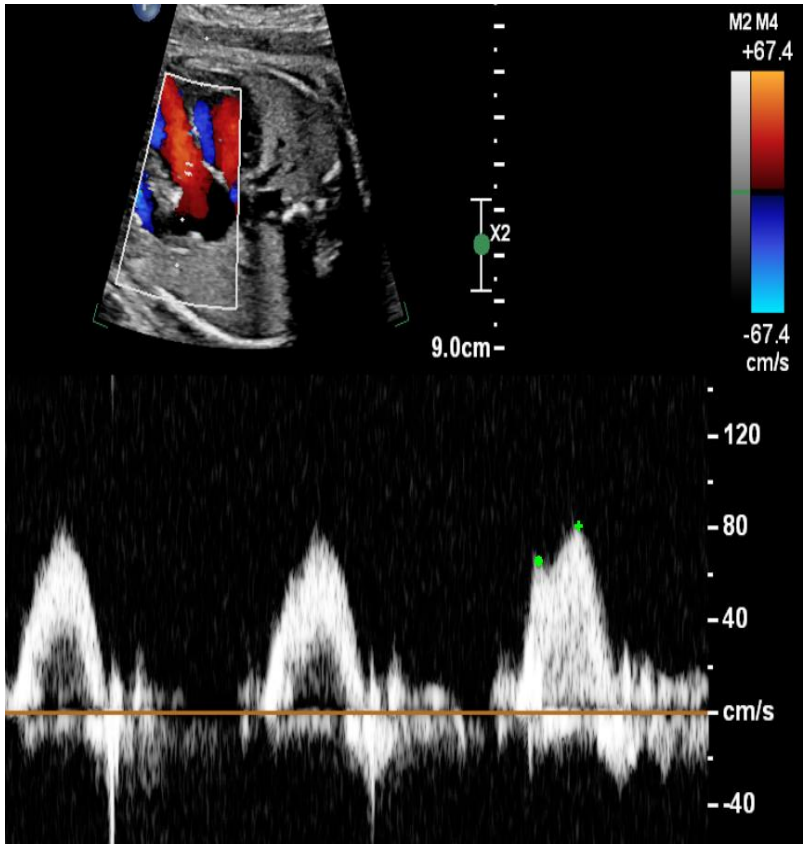
Peak flow velocity should not be above 1m/sec for either valve

Normal value is 0.3-0.7 m/sec

Tricuspid Valve,Apical4C view







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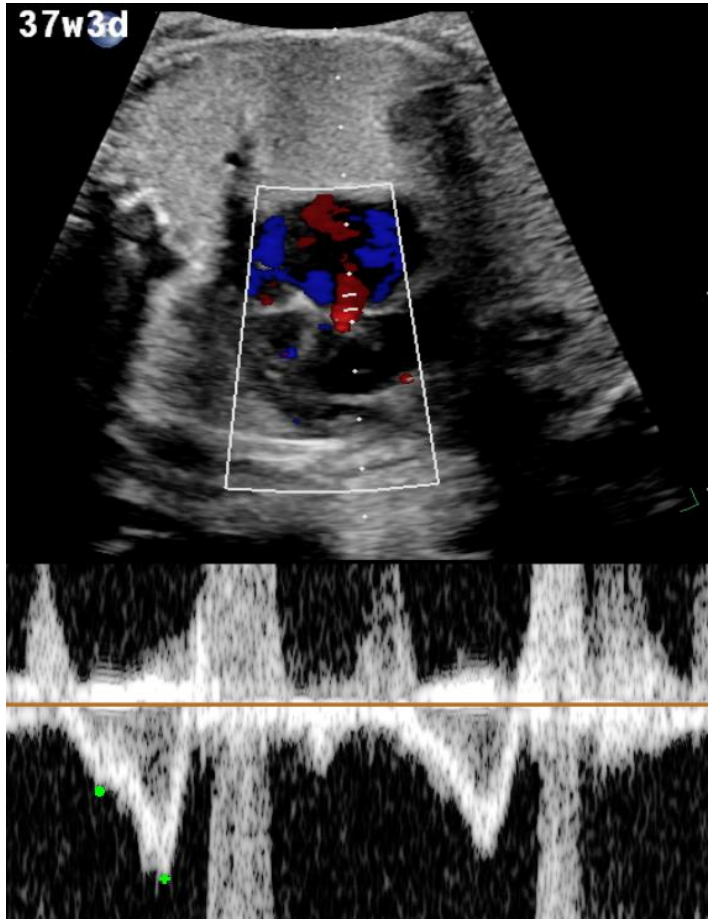
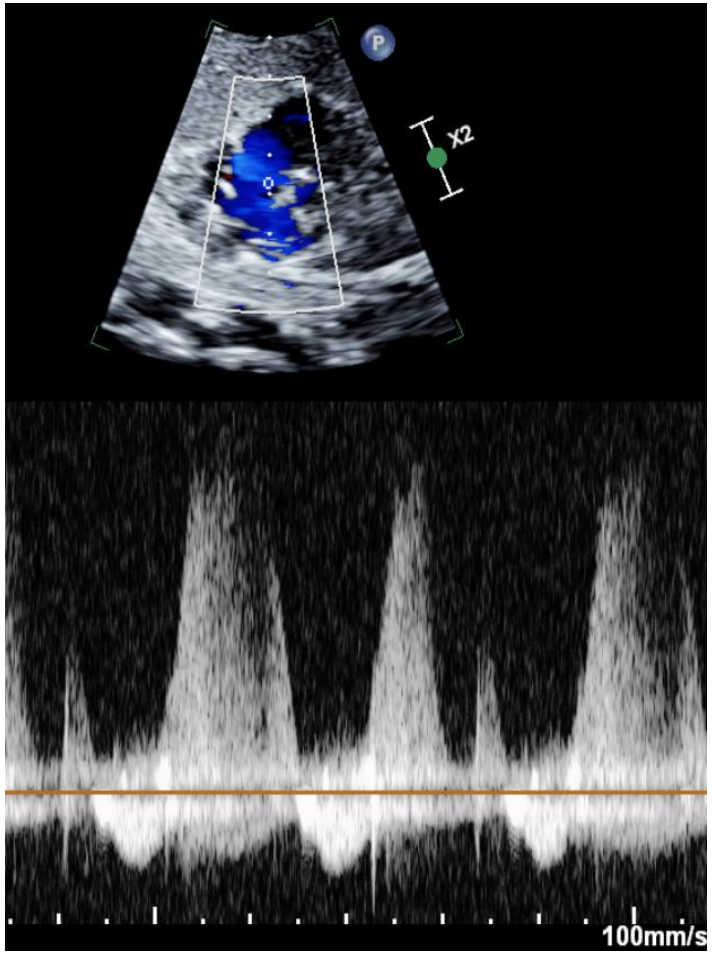
Mitral/Tricuspid Regurgitation





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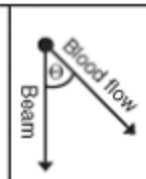
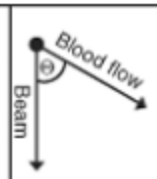
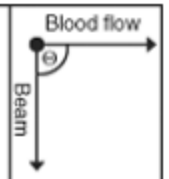
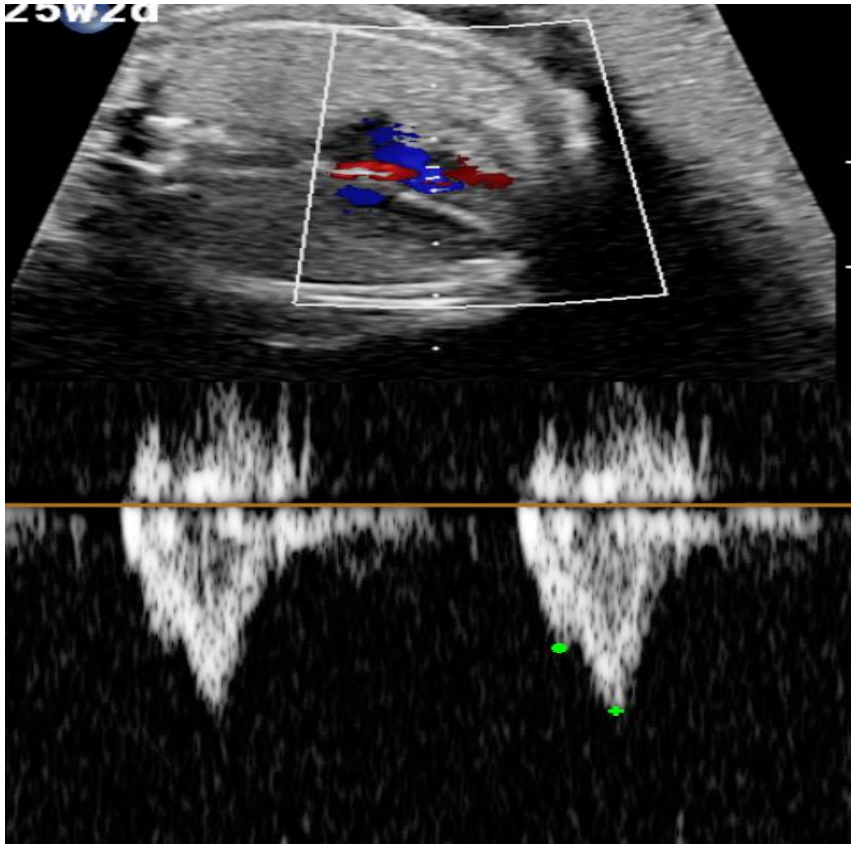
AV Valves- Mitral and Tricuspid Valves

Incorrect Doppler angle:

					
Angle (Θ)	**0**	**30**	**45**	**60**	**90**
Cosine of Θ	1	0.87	0.7	0.5	0
Measured velocity	5 m/s	4.35 m/s	3.5 m/s	2.5 m/s	0 m/s



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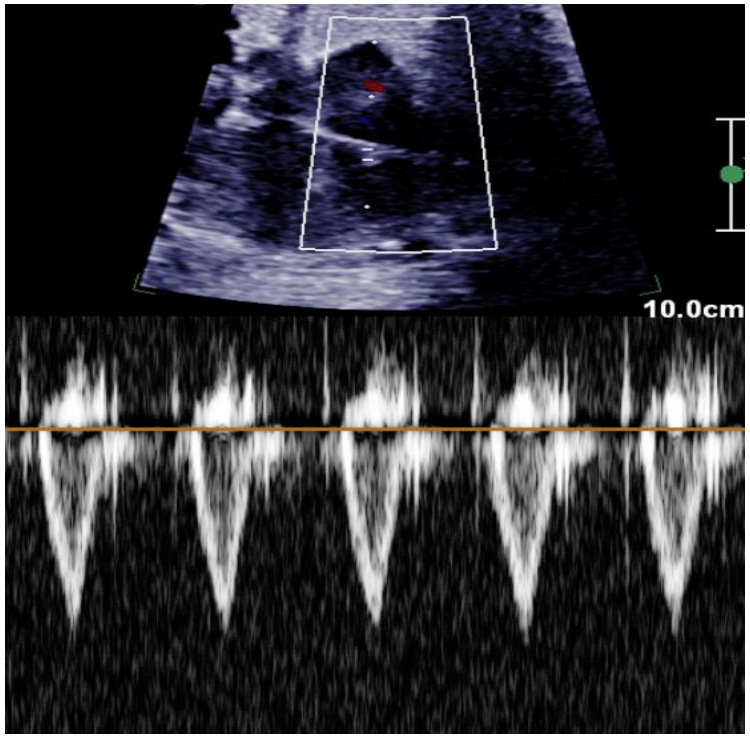
AV Valves- Mitral and Tricuspid Valves

Abnormal: Monophasic or Fused



Causes:

Rapid heart rate,(svt,tachy)

Myocardial hypertrophy

Ventricular dysfunction

Misplaced sample volume (too far into the LV)

Incorrect angle of interrogation

Semilunar Valves, Ventricular Outflow

Optimizing Doppler angle:

Good 2D image: Long axis of LVOT (apical 5C/3C)

Ideal Doppler angle should be zero-Smallest angel possible, <30

Do not use angle >60 - No flow at 90 degrees

Place the sample volume at brightest area of flow

Keep sample volume small for small areas

Color scale around 70m/sec-arterial blood flow

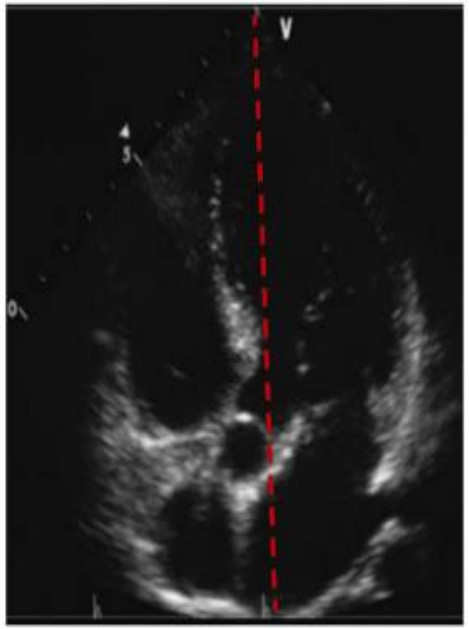
Optimize spectral Doppler waveform: scale, baseline adjustments

Lower frequency probe sometimes helpful

Great angle for PV

AV/PV Doppler Angles

Incorrect

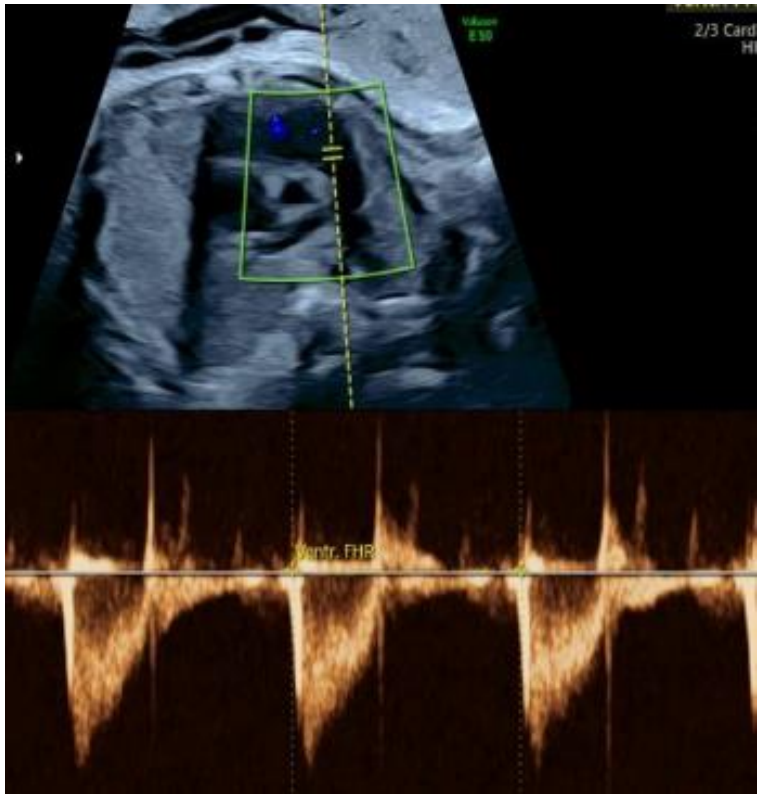


Standard AP5

Correct

Modified AP5

Normal AV value: 0.5-0.90m/sec up to 1.0 at term



Normal PV value: 0.70 m/sec (22-24 GA)

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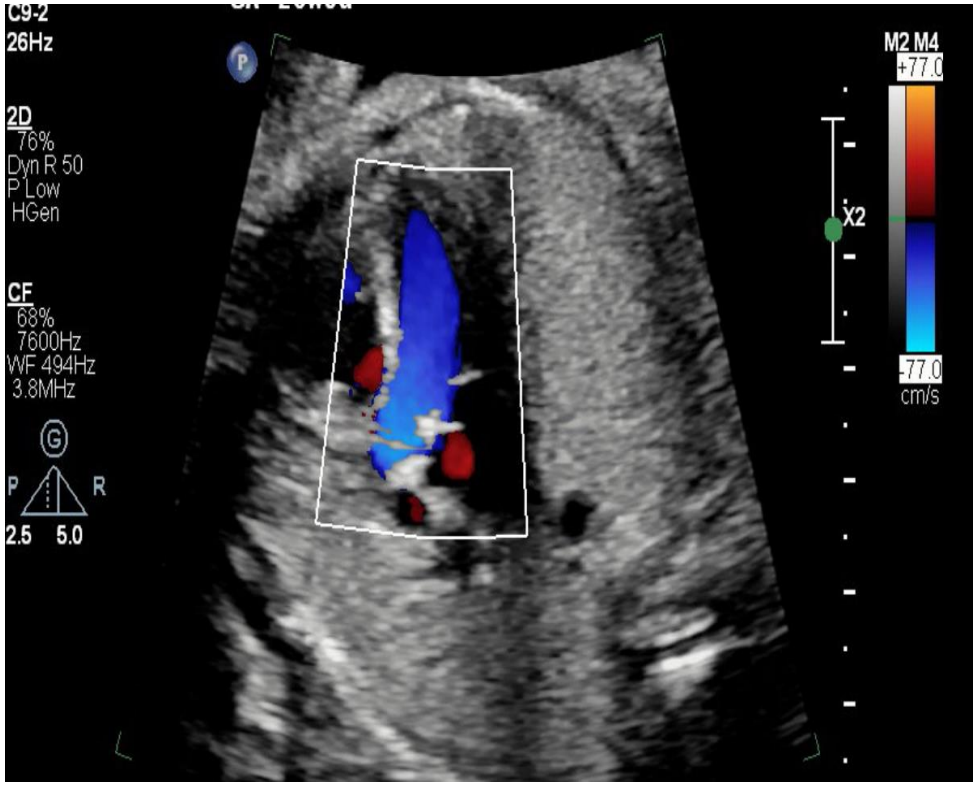
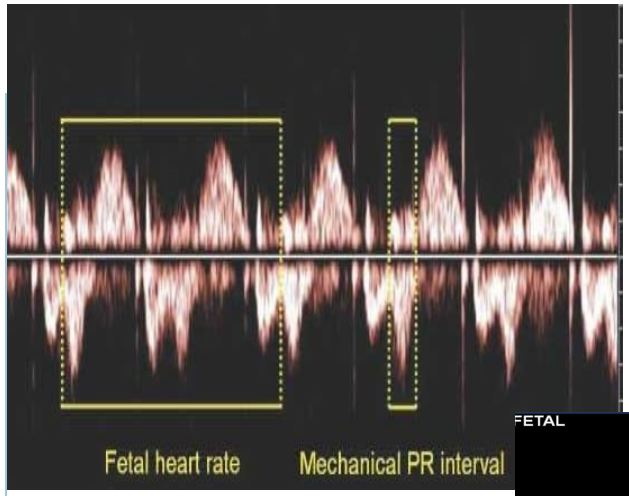
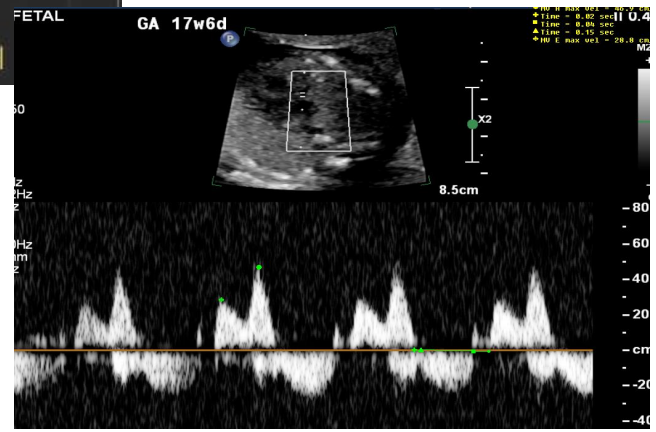
Ventricular inflow and outflow Doppler







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Cardiac Output: LVOT/RVOT

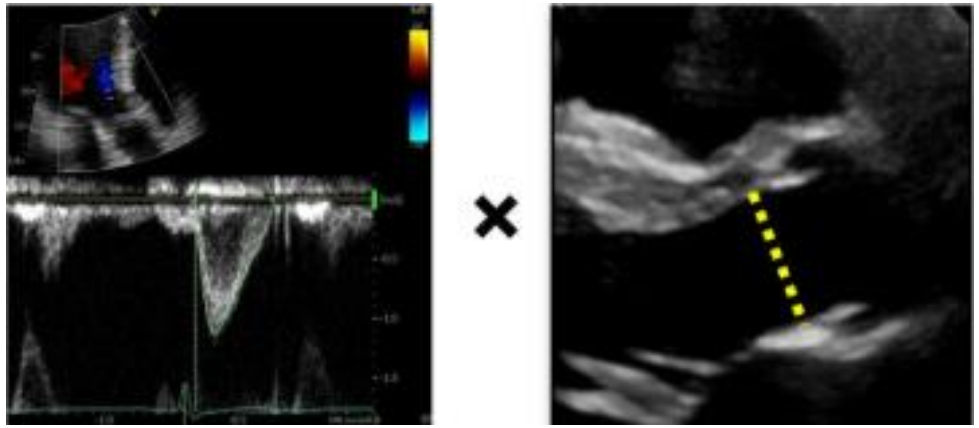
Obtain RVOT/LVOT pulsed wave Doppler VTI

Good 2D image of the CSA AV/PV

HR

Normal CO 400-500mL/kg/min

300-400mL/kg/min less than18 wk



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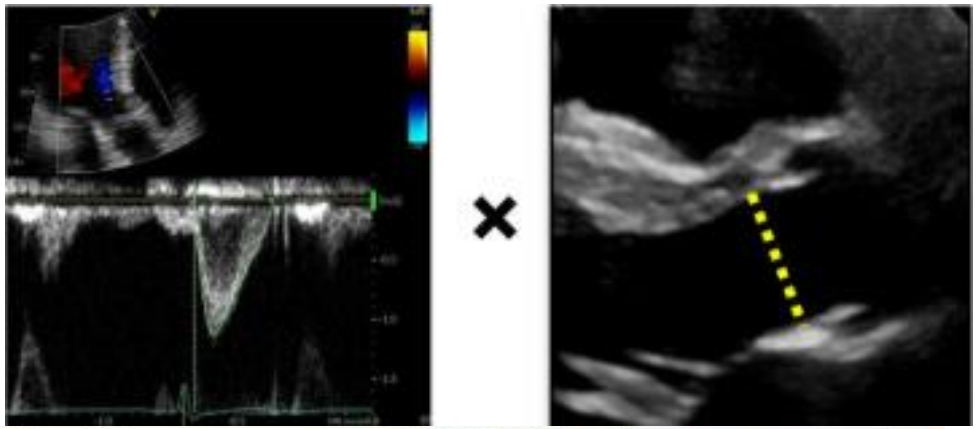
Cardiac Output:



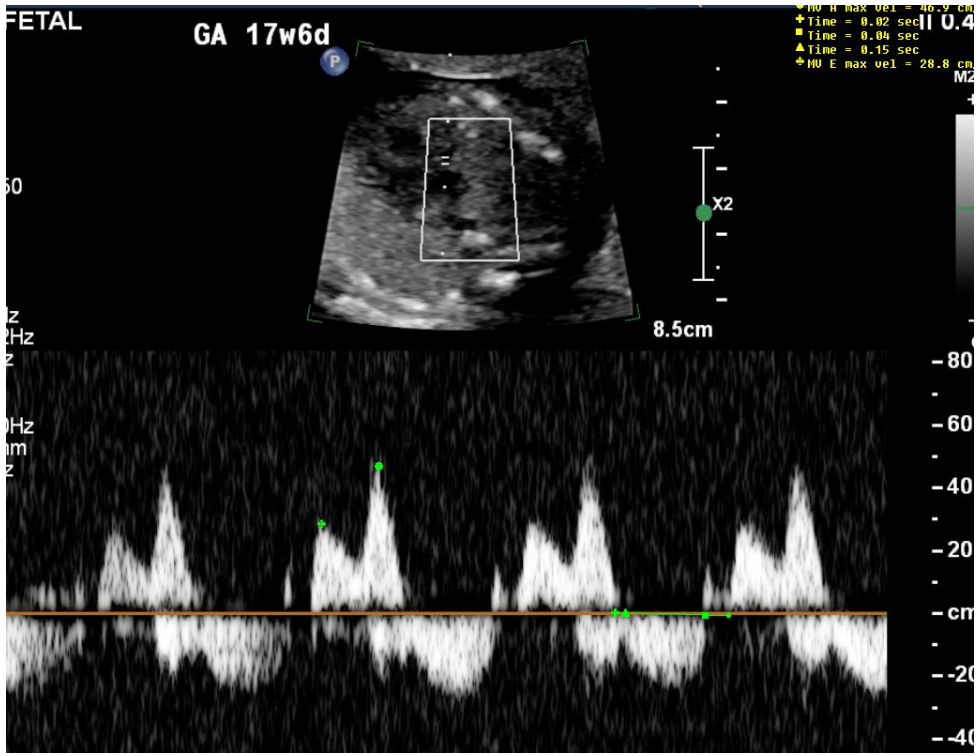
The Measurement Pitfalls Matrix

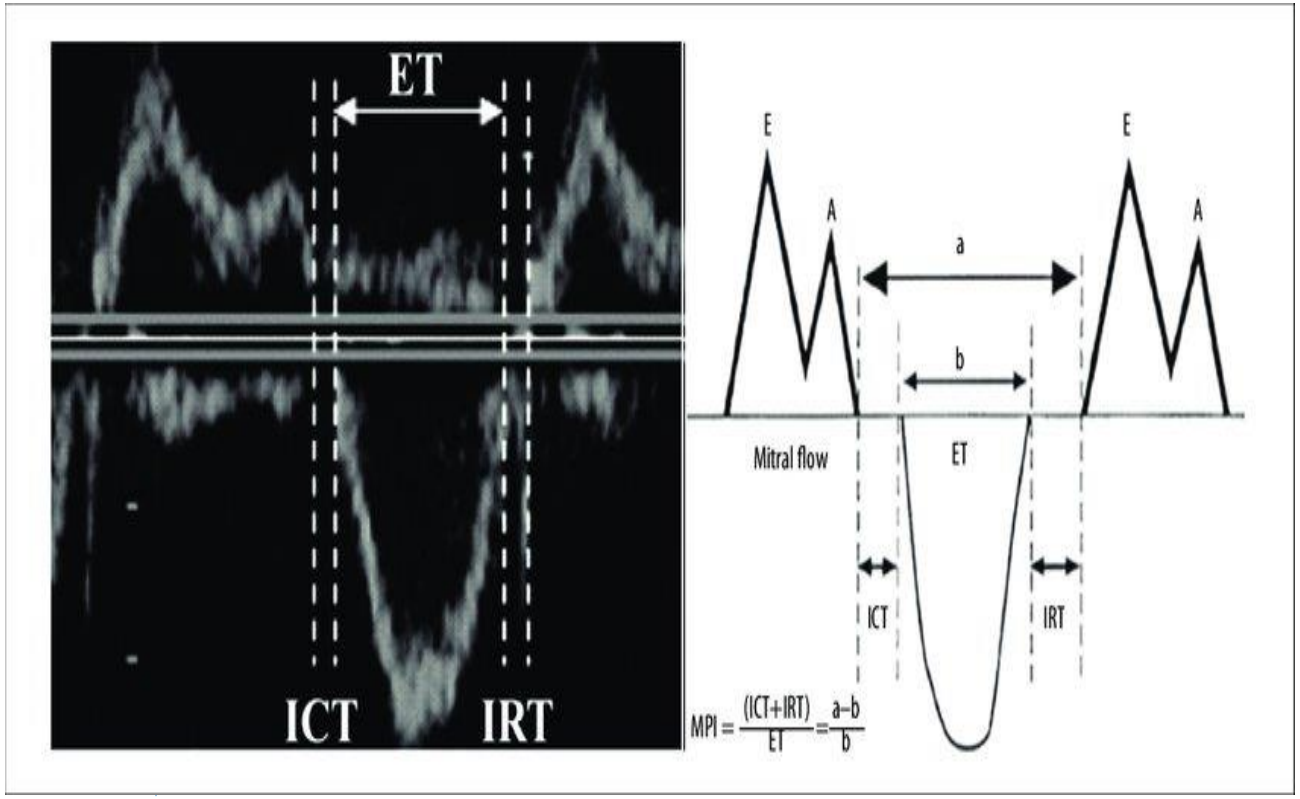
The Error	The Consequence	The Fix
⚠ Measuring in diastole	Falsely low area & CCO	Always freeze in mid-systole (leaflets open)
⚠ Outer-wall to outer-wall	Exponentially overestimates area	Use leading-edge / inner-edge technique
⚠ Outer PA diameter used	Overestimates RVOT area	Measure strictly at valve leaflet level
⚠ Sample volume too distal	Captures post-valve turbulence	Keep 2-3mm sample at annular level
⚠ Doppler angle > 20°	Underestimates peak velocity (low VTI)	Correct angle or reposition transducer
⚠ Single measurement	High variability	Average 3 measurements across 3 cycles

Gestation (weeks)	Aortic VTI (cm)	Pulmonary VTI (cm)	LV Stroke Vol (ml)	RV Stroke Vol (ml)
20	6 – 8	7 – 9	~0.7	~0.7
24	8 – 10	9 – 12	~1.2	~1.5
28	10 – 13	11 – 14	~2.0	~2.6
32	12 – 15	13 – 16	~3.0	~4.0
36	13 – 16	14 – 18	~4.0	~5.5
40	14 – 18	15 – 19	~5.2	~7.6

Gestation (weeks)	LV Output ml/min	RV Output ml/min	CCO 50th centile ml/min	CCO range ml/min
20	~80	~120	~200	120 – 320
24	~160	~240	~400	250 – 580
26	~210	~310	~520	330 – 740
28	~265	~385	~650	420 – 900
30	~330	~480	~810	520 – 1,100
32	~390	~560	~950	620 – 1,300
34	~391	~573	~964	640 – 1,340
36	~490	~760	~1,250	820 – 1,650
38	~560	~840	~1,400	900 – 1,850
40	~600	~870	~1,470	950 – 2,000

Ventricular Inflow Outflow Doppler: MPI, or Functional Cardiac Assessments





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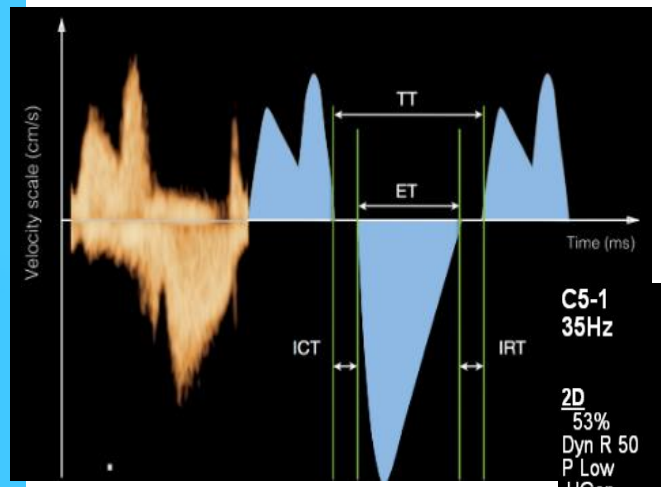
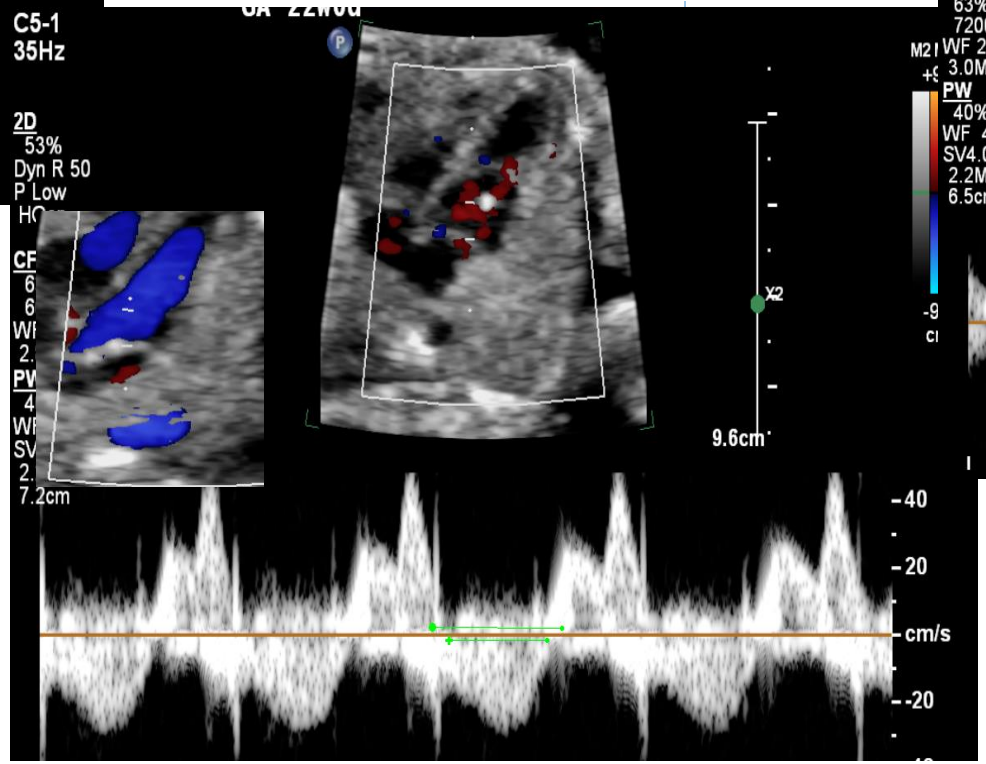
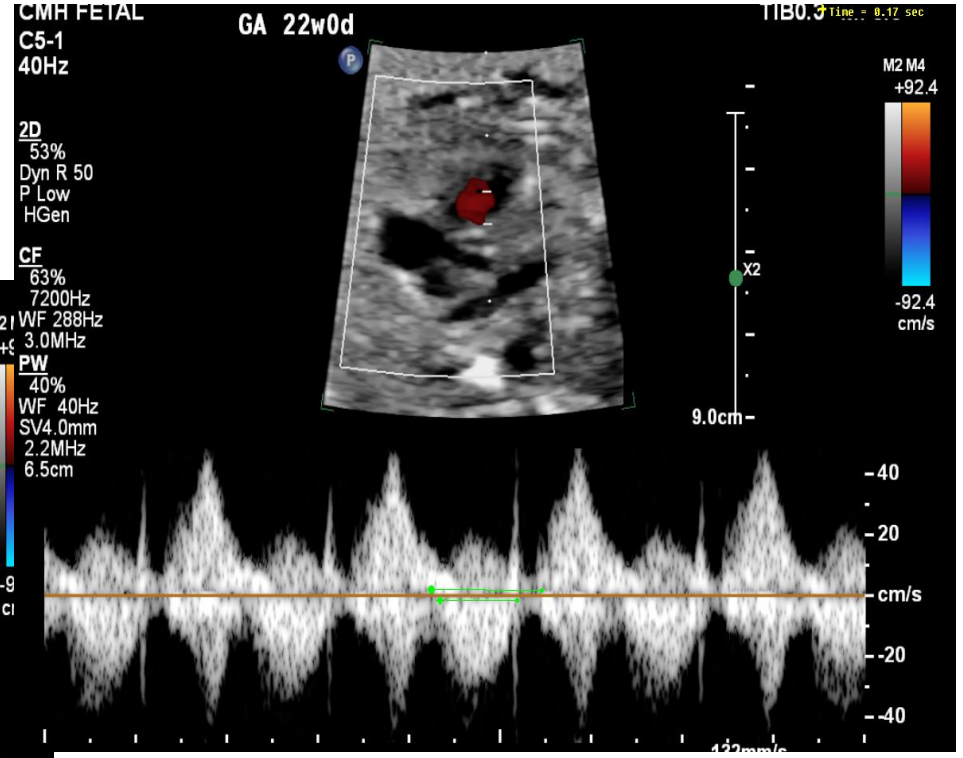
Myocardial Performance Index



$$MPI = \frac{IVCT + IVRT}{ET}$$





MPI: Systolic and Diastolic ventricular function assessment:

Table 11 Types of hemodynamic derangement caused by fetal conditions

Hemodynamic derangement	Fetal condition	Common abnormalities detected by echocardiography
High-cardiac output lesions[73-75]	• Arteriovenous malformation • Agenesis of ductus venosus • Fetal anemia • TRAP • TTTS • Vascular masses/tumors	• Elevated CCOi • Cardiomegaly (CTAR) • AV valve regurgitation • Abnormal or normal vein Doppler • LV/RV systolic dysfunction • Hydrops
Increased preload (volume overload)[76,77]	• AVSD with severe AV valve regurgitation • Complete AV block • TOF/absent pulmonary valve	• Elevated MPI • Systolic dysfunction • Abnormal venous Doppler • Cardiomegaly (CTAR) • Hydrops
Increased afterload lesions[78,79]	• Bilateral semilunar valve stenosis including truncal valve stenosis • Constriction of the ductus arteriosus • TTTS	• Elevated MPI • AV valve regurgitation • Diastolic dysfunction • Abnormal venous Doppler • Hydrops
Cardiac compression (decreased preload)[75,80-82]	• CDH • CHAOS • CPAM	• Low CCOi • Abnormal tricuspid inflow and/or venous Doppler (CHAOS, CPAM) • Hydrops • Left heart compression, reduced LV stroke volume (CDH)

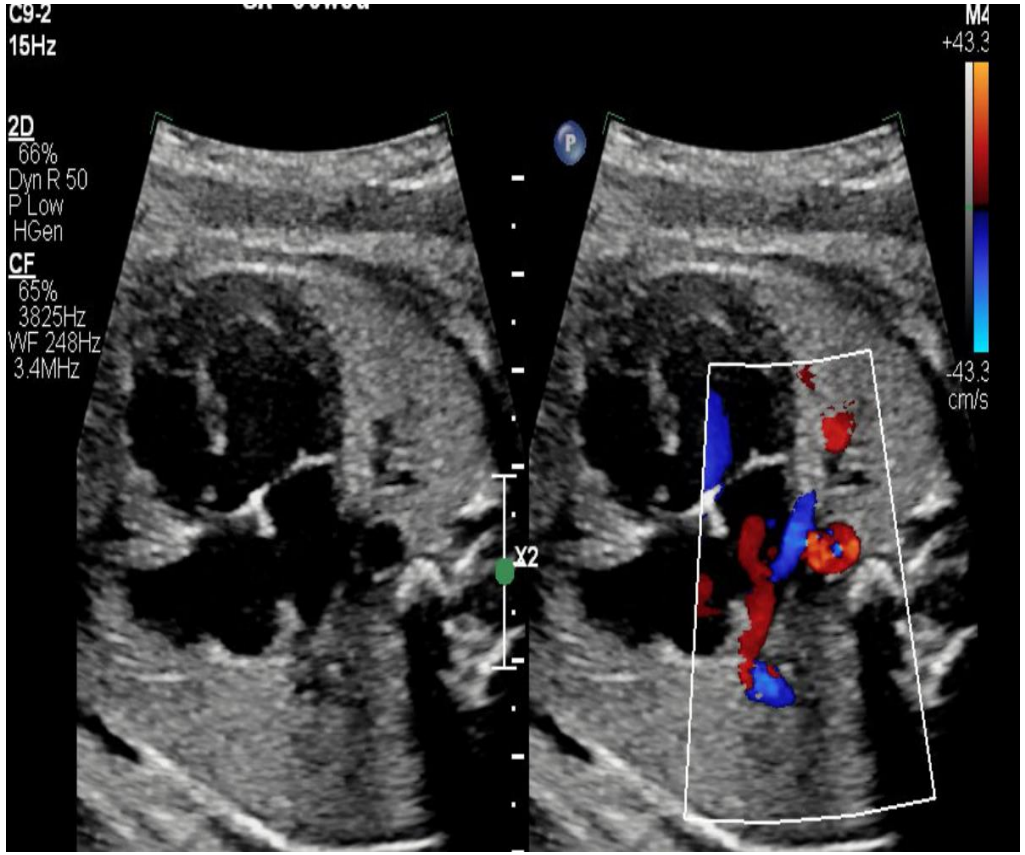
AVSD, Atrioventricular septal defect; *CCOi*, combined cardiac output index; *CDH*, congenital diaphragmatic hernia, *CHAOS*, congenital high-airway obstruction; *CPAM*, congenital pulmonary airway malformation; *CTAR*, cardiothoracic area ratio; *MPI*, myocardial performance index; *TRAP*, twin-reversed arterial perfusion; *TTTS*, twin-twin transfusion syndrome.

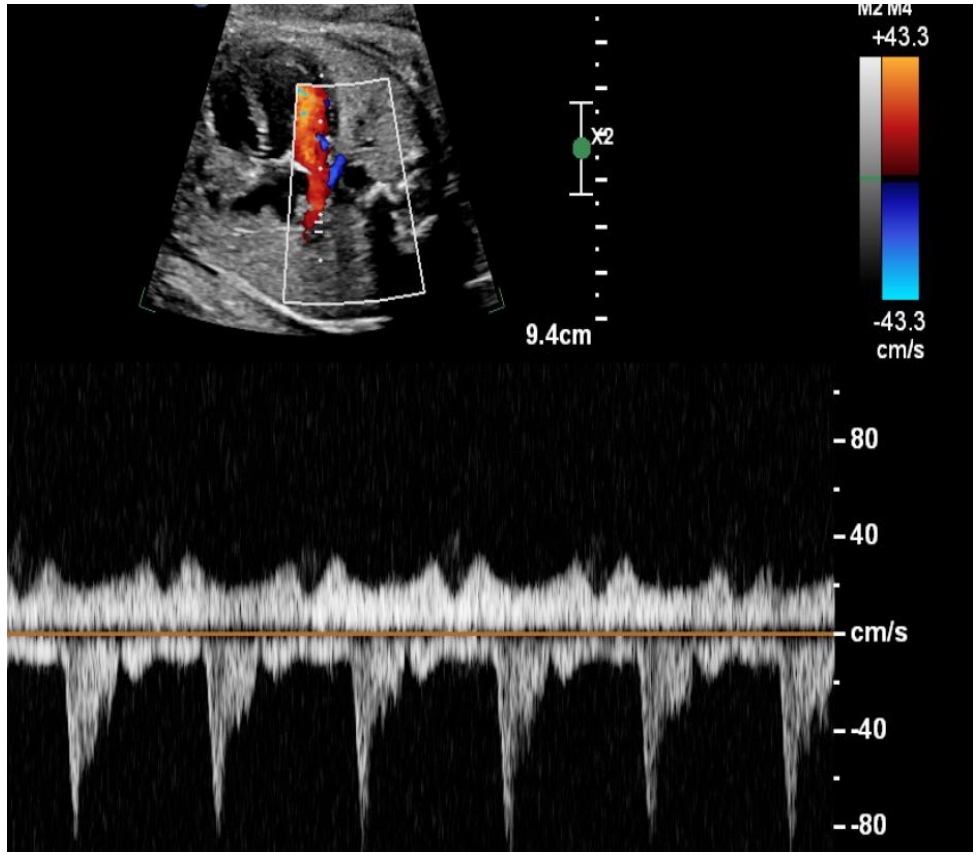
Normal references Values vary by population age, Disease state, (TTTS, recipient vs donor, FGR, maternal Diabetes, Preeclampsia, and CHD)
but typical range:

Approximately 0.35-0.45 in normal fetuses from mid to Late gestation

Thresholds:
0.46-0.55: Mild dysfunction, warrants enhanced monitoring
0.56-0.65: Moderate dysfunction, potential intervention
0.65: Severe dysfunction, urgent clinical assessment

Pulmonary Veins





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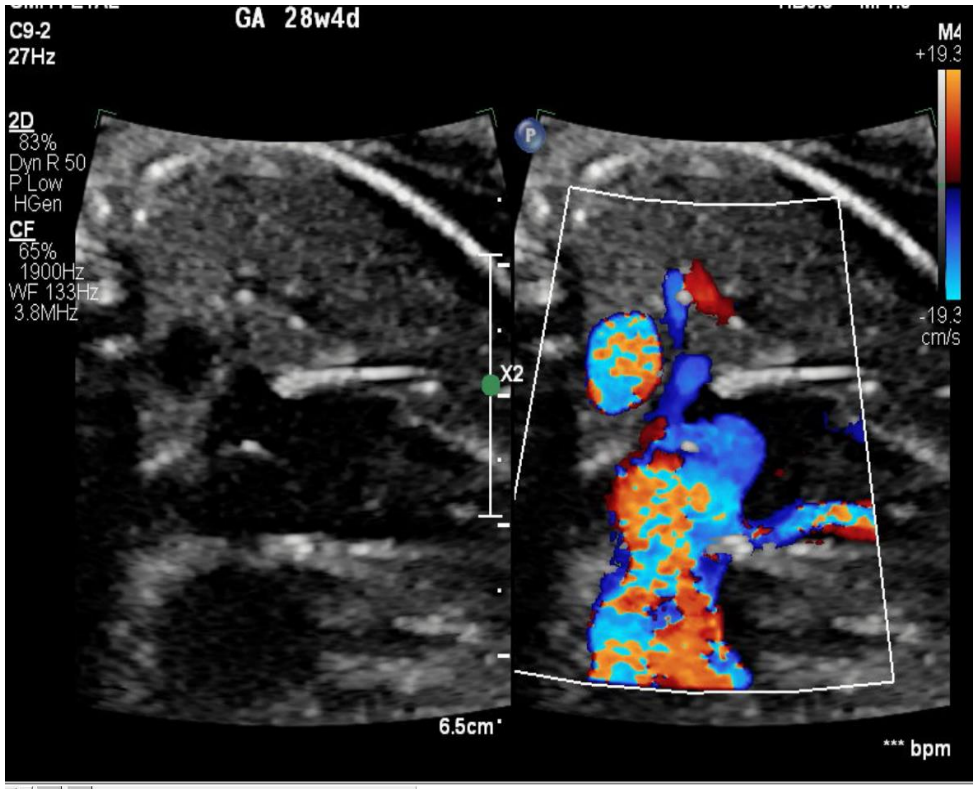
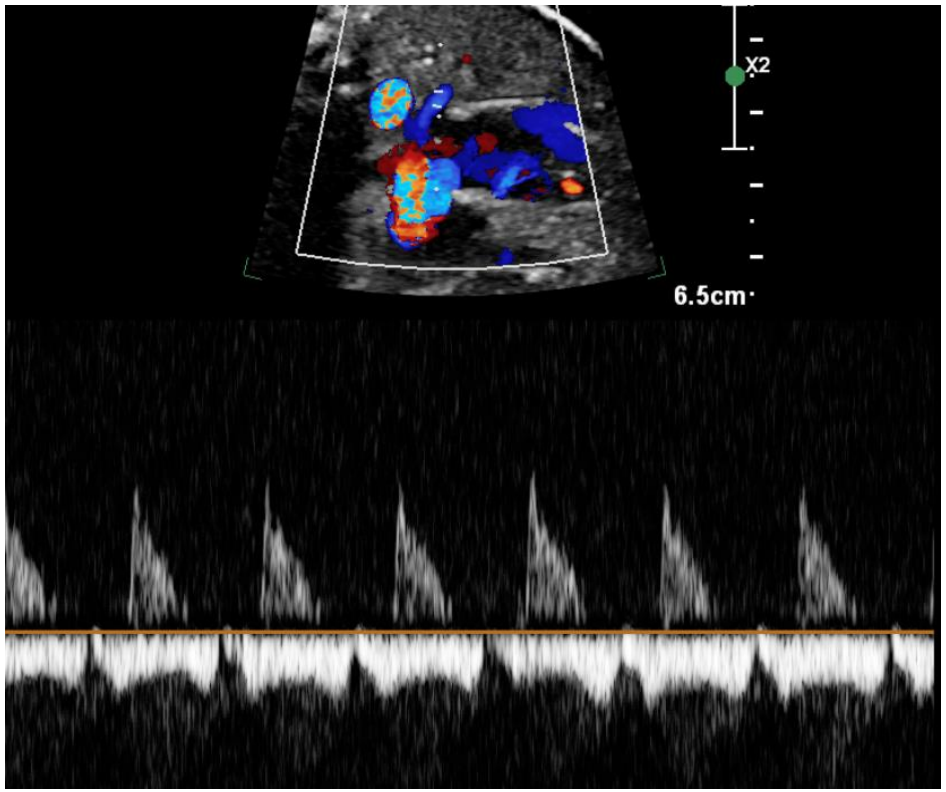
Pulmonary Veins: Coronal





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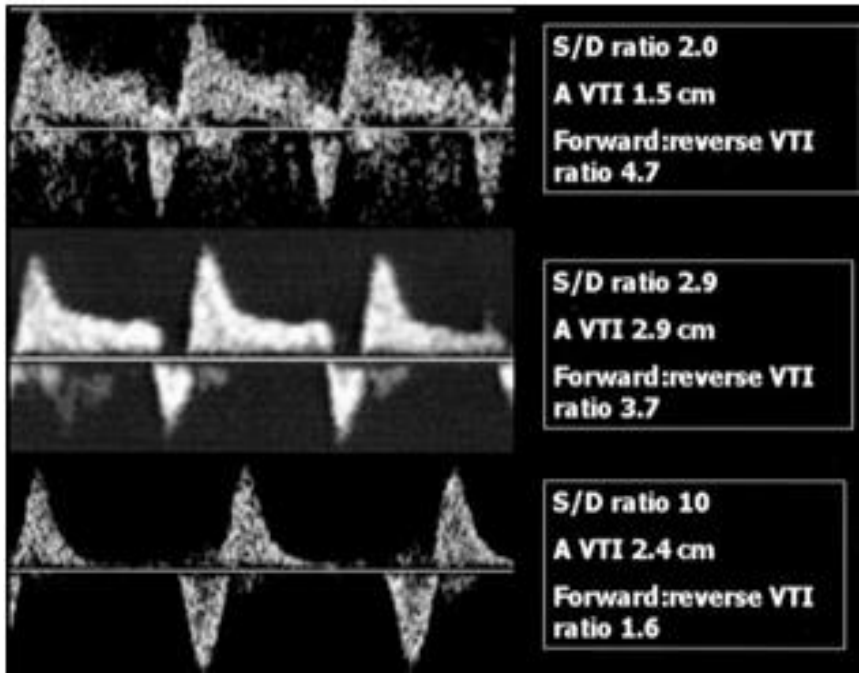
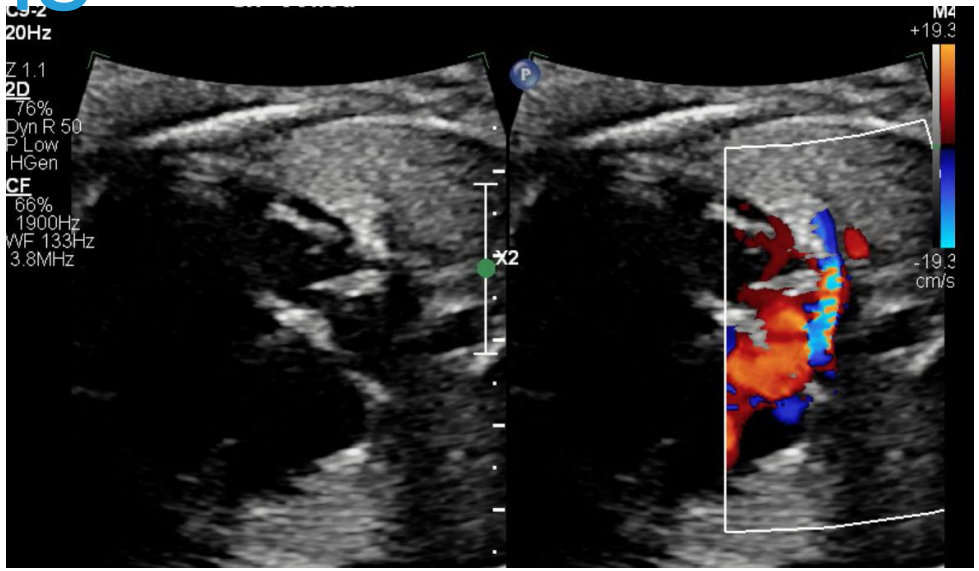
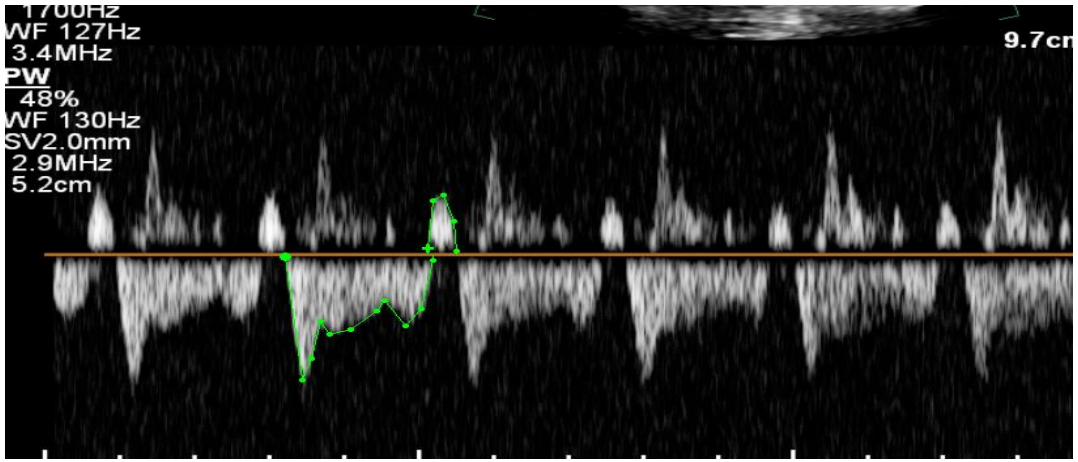
HLHS: Pulmonary Veins







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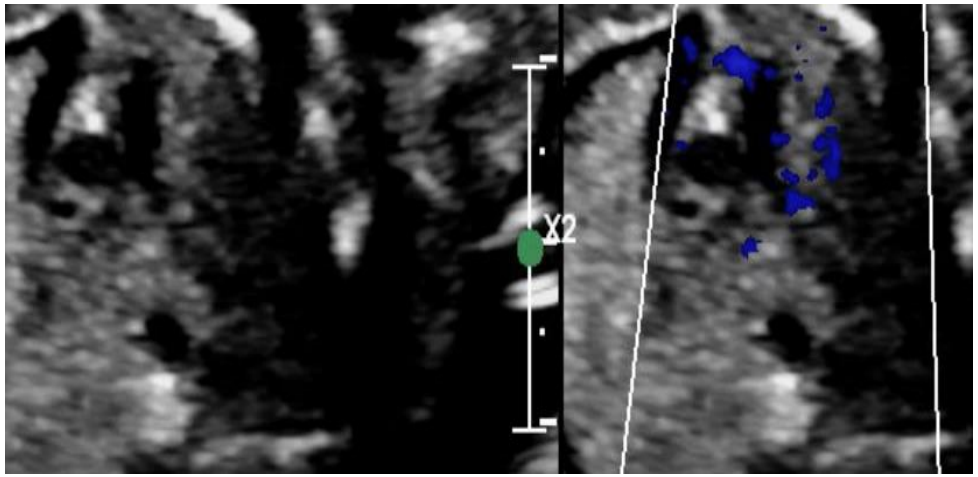
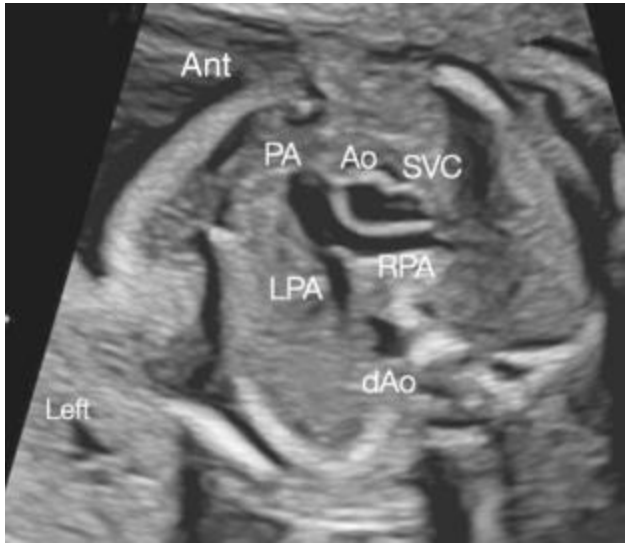
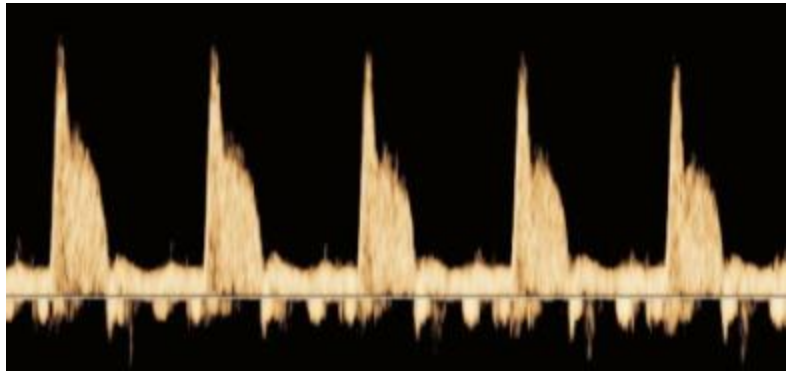
Pulmonary Arteries







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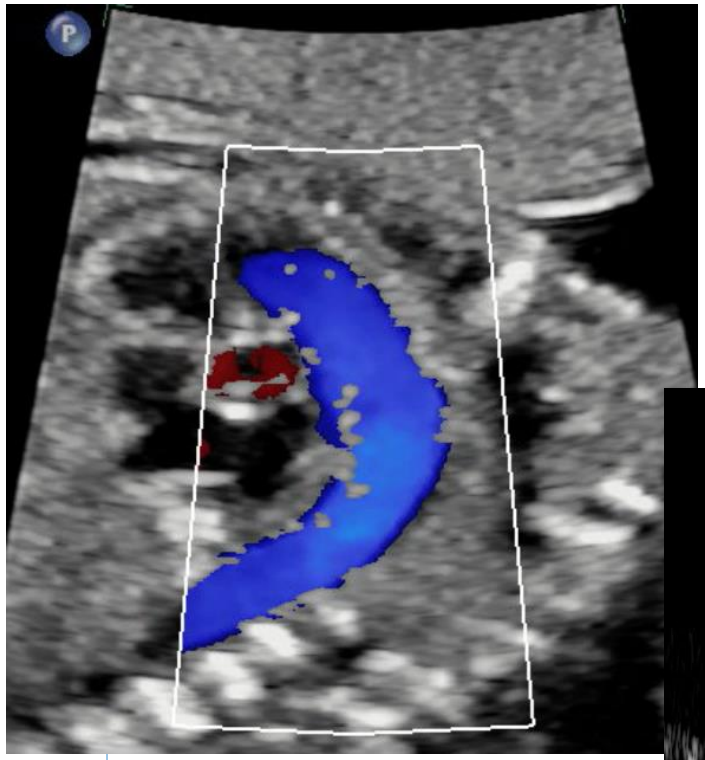
Patent Ductus Arteriosus

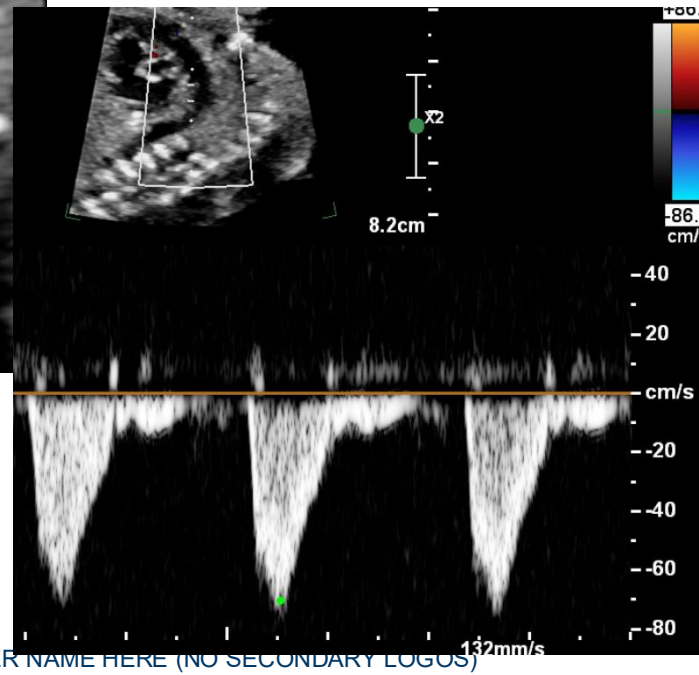
Largest artery in the fetus

Connects PA and Dao

Right to left shunt in the fetus (normally)

Closes after birth within hours to days



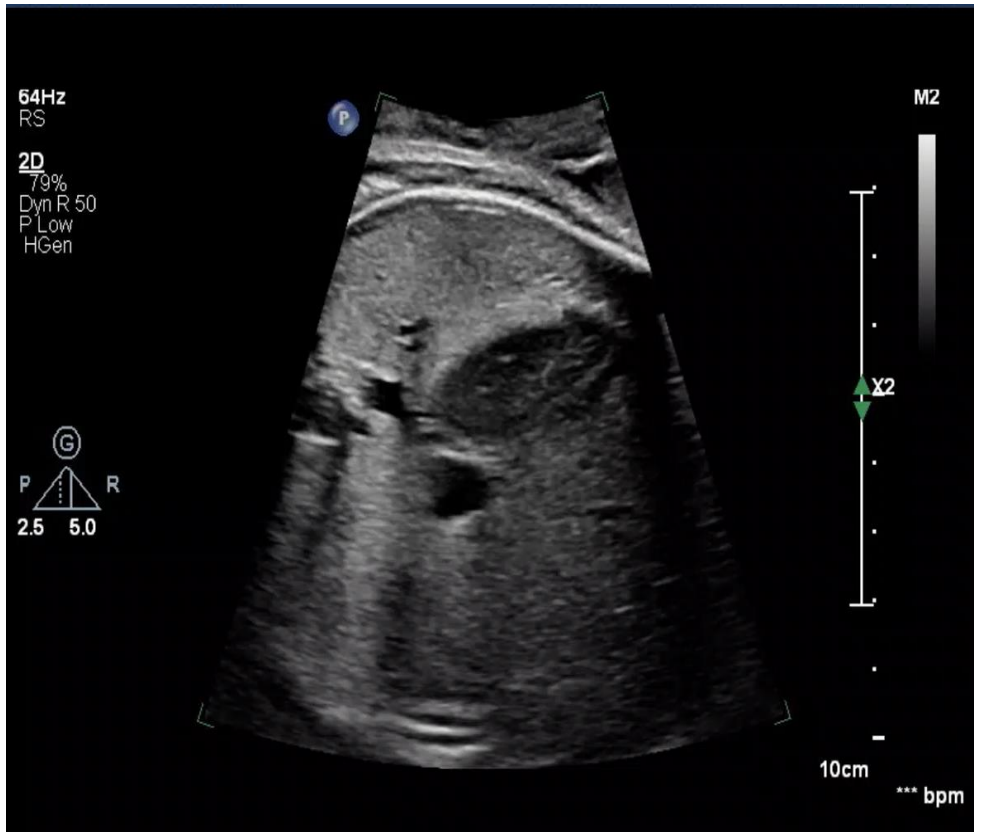


Restrictive/Premature closure of ductus arteriosus

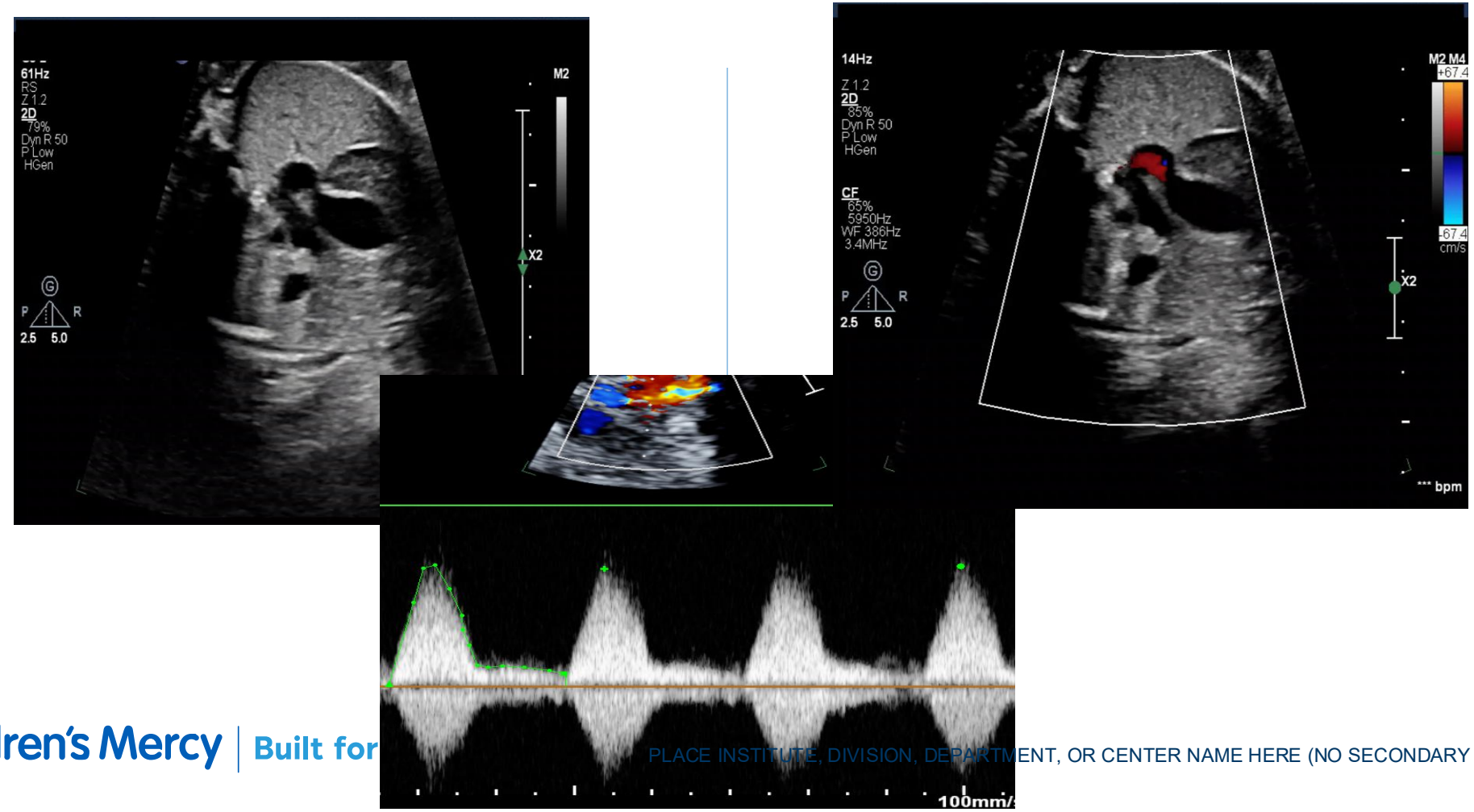
Ductal constriction or closure causes serious problems in the fetus:

- Right heart failure
- Hydrops

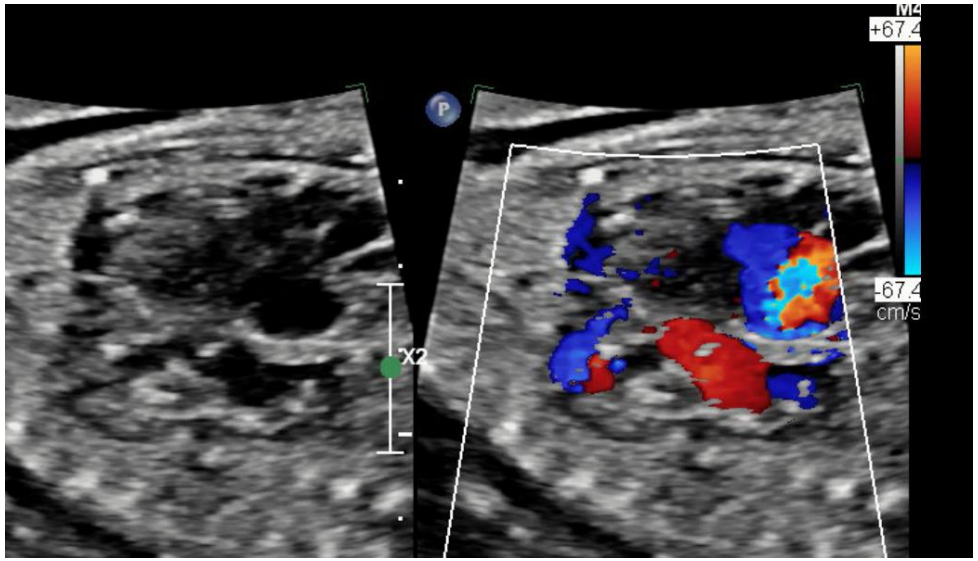
Constricted with aspirin and other prostaglandin synthesis inhibitors

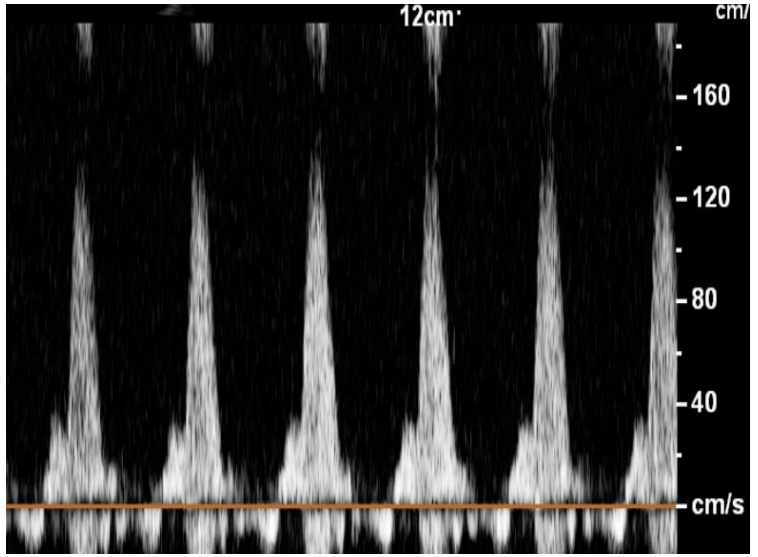


Ductal Constriction



Ductus: TV dysplasia vs Ebsteins





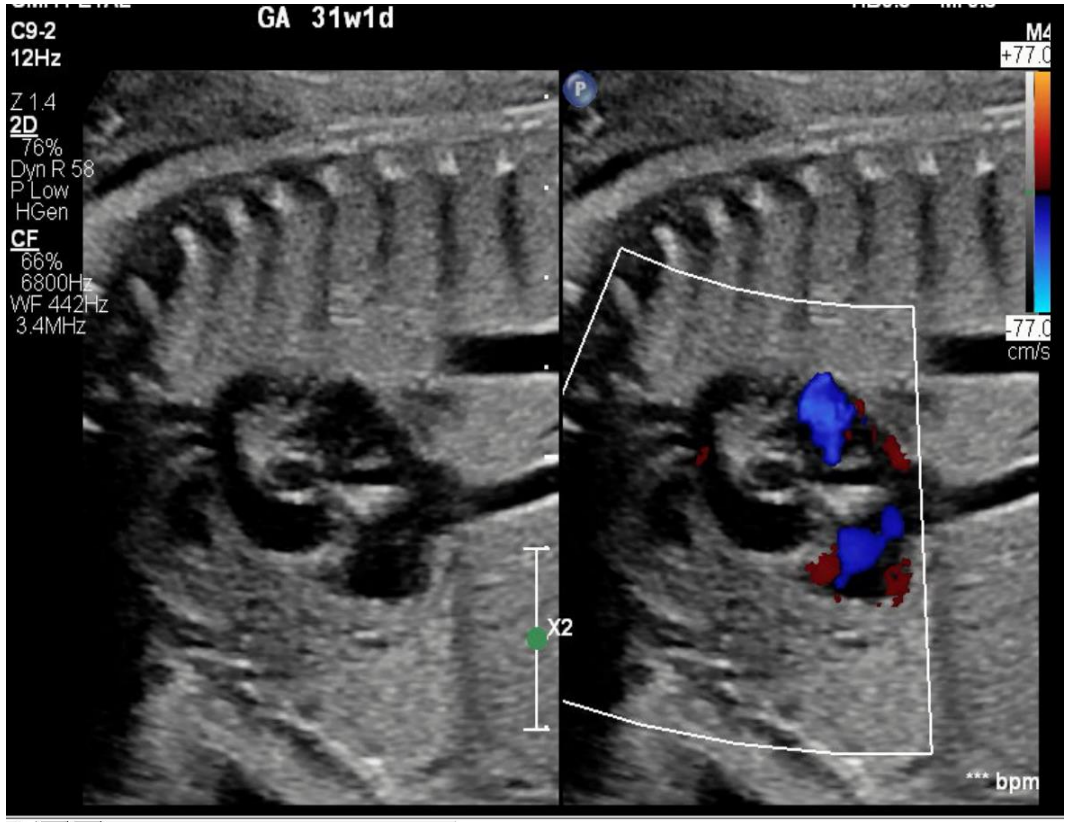
Aortic Isthmus/Aortic Arch

2D: Long axis of the aortic arch from oblique sagittal

Optimize CFM box to include the entire arch with branching arteries

Gate: small to medium

Scale: set for arterial flow (optimizing for 60-80cm/s)



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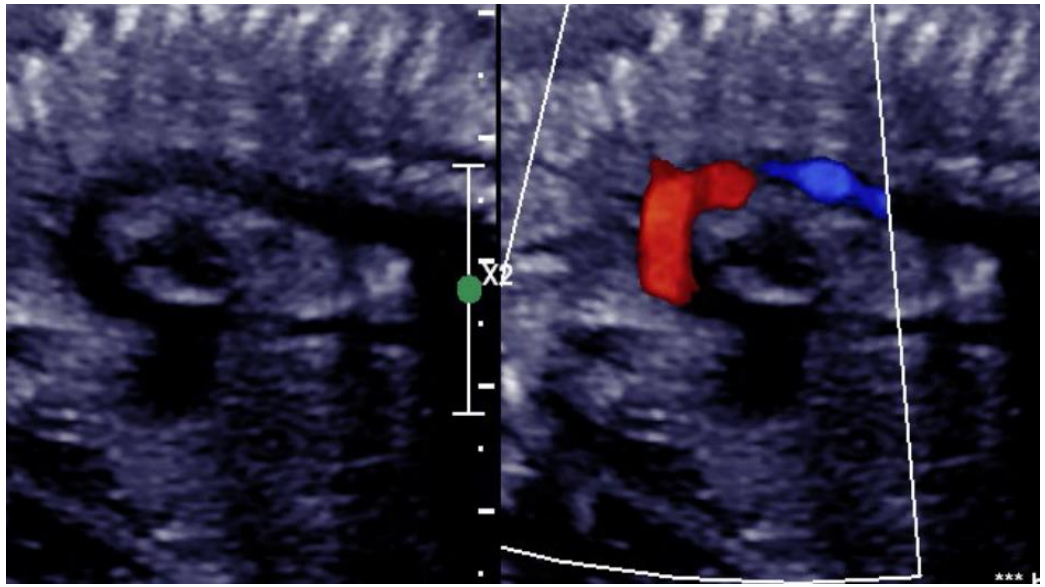
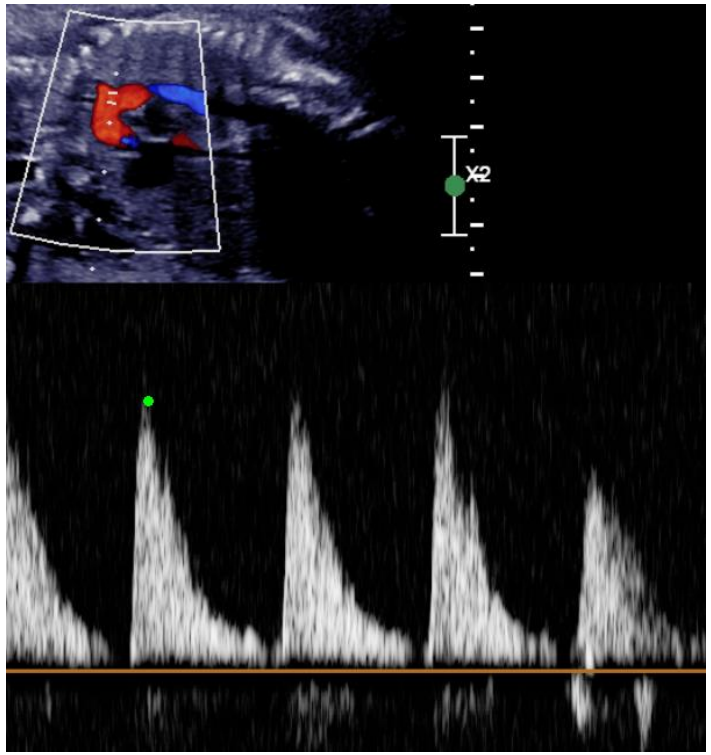
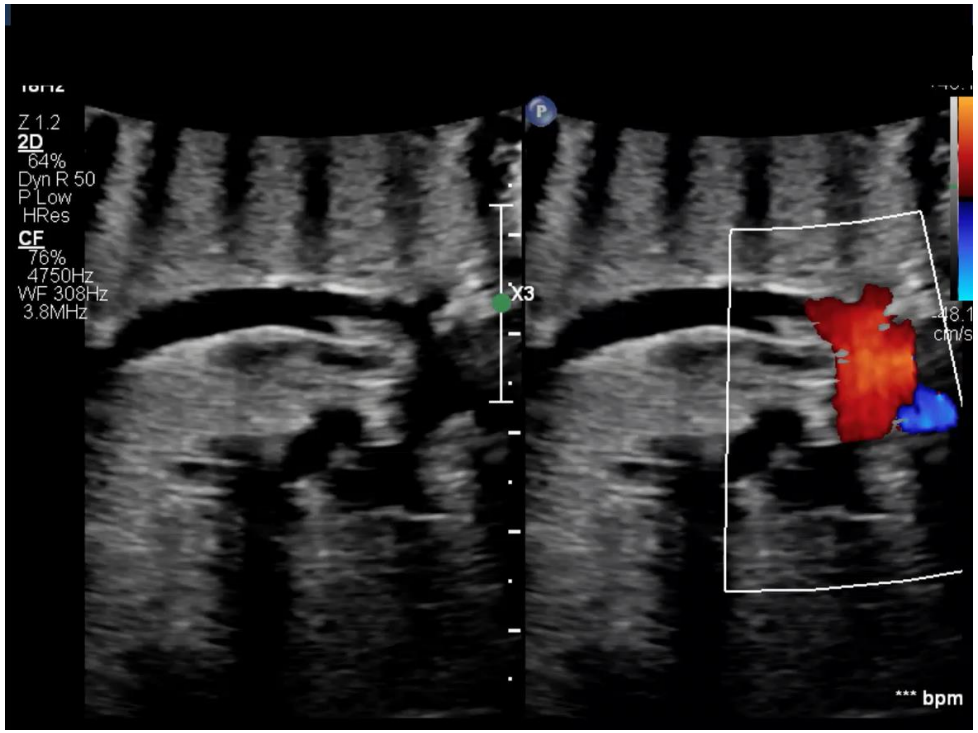
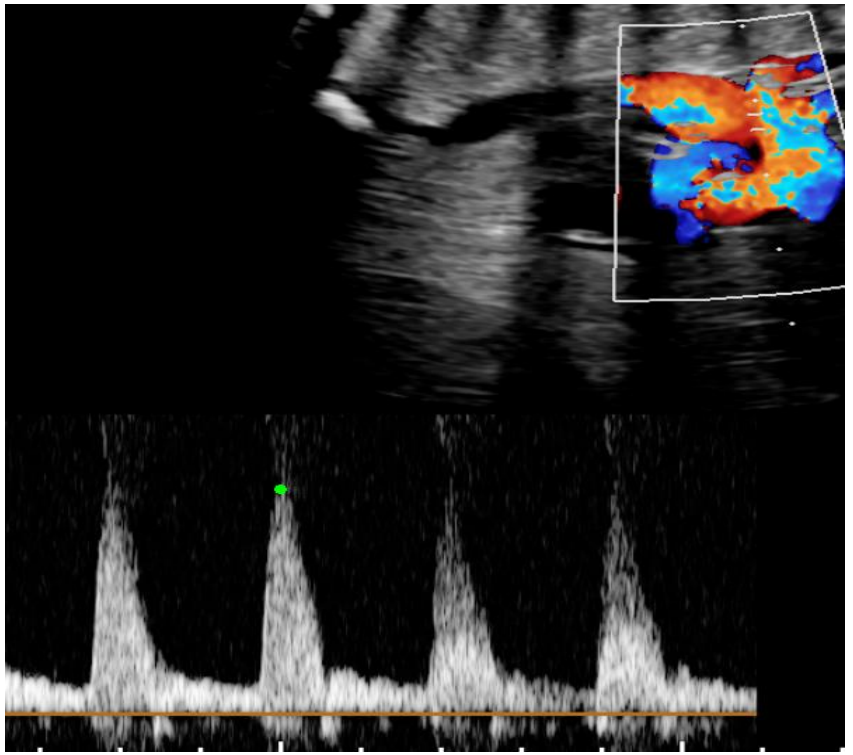
Normal flow aortic arch/isthmus



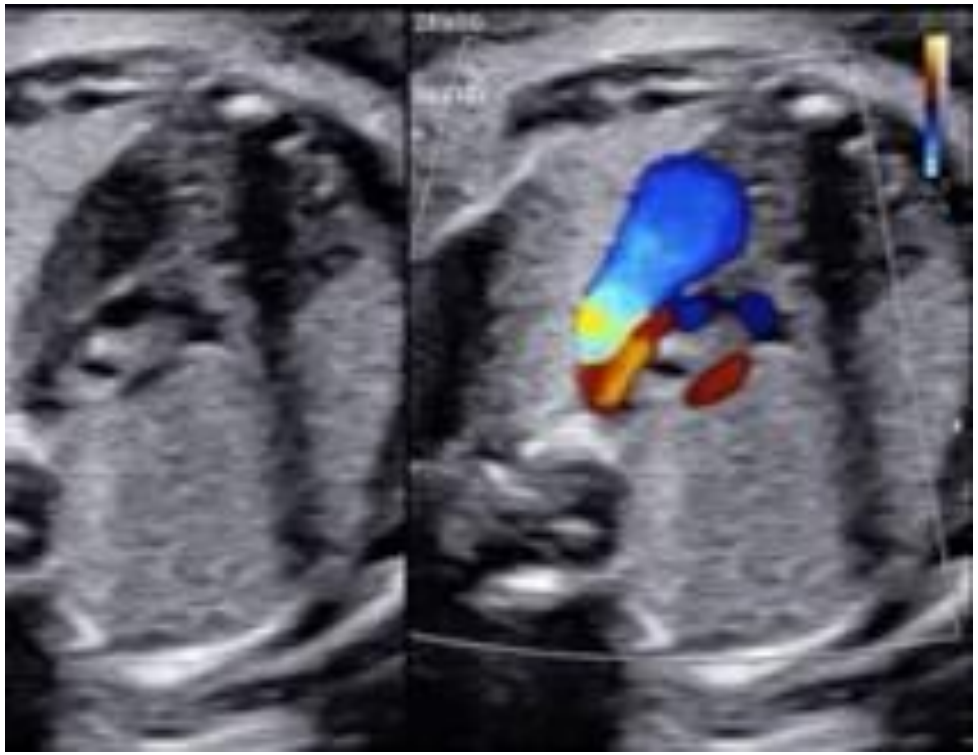
Normal velocities 0.7-1.0 m/sec




Z 1.2
2D
64%
Dyn R 50
P Low
HRes
CF
76%
4750Hz
WF 308Hz
3.8MHz
X3
*** bpm



Retrograde Arch flow: HLHS

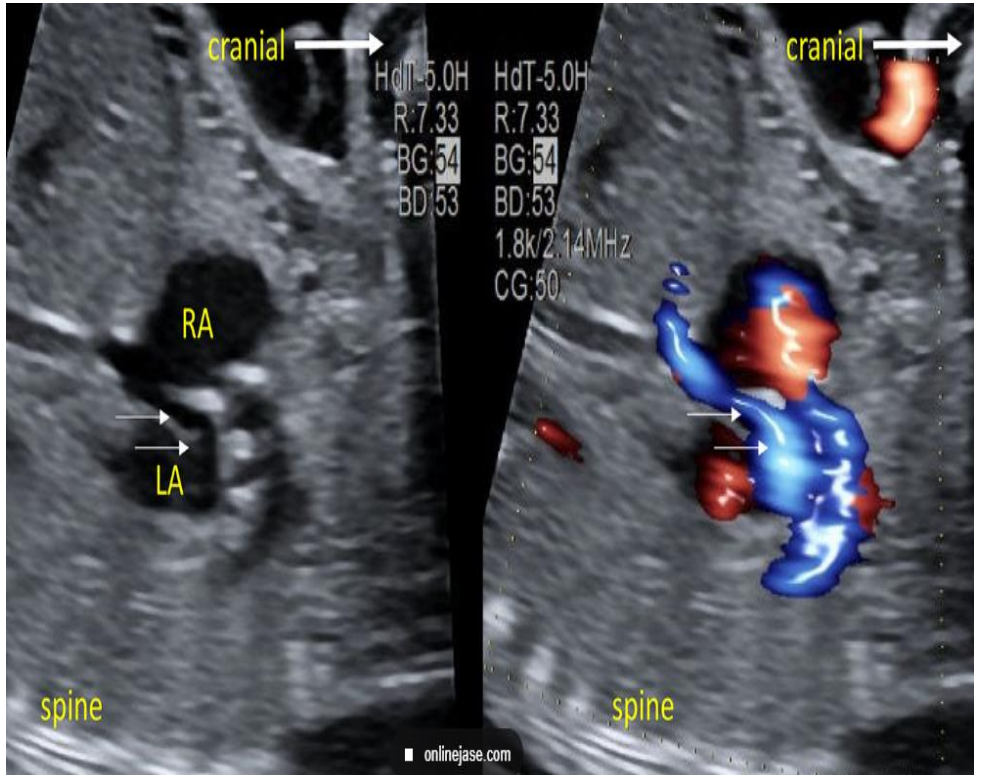


PFO- Patent Foramen Ovale

Opening in the septum primum, partially covered by septum secundum

High O2 content blood shunted to the left heart and brain

Closes in 80% of people withing months to years after birth

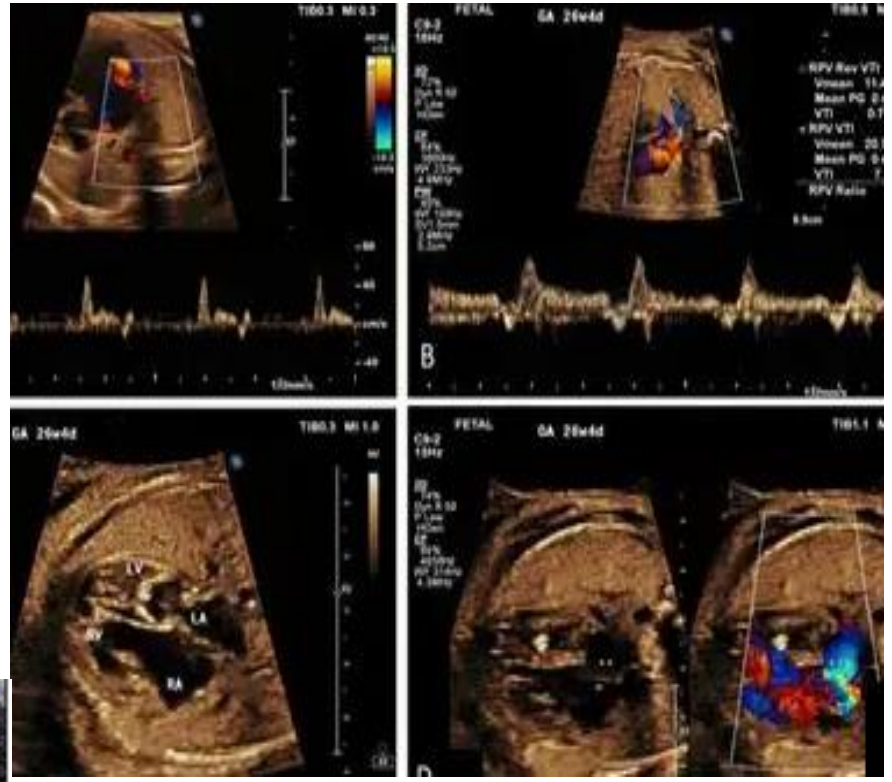


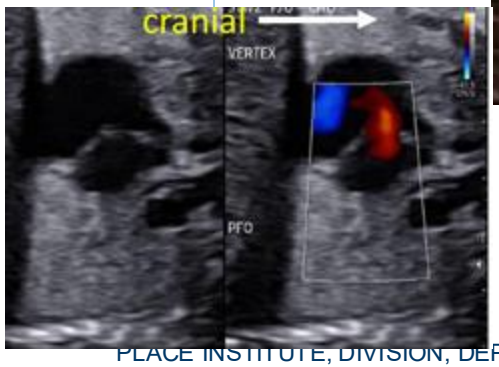
Role of PFO in complex CHD

Problem anomalies:

HLH: LAP, shunting L-R, blood flow away from LV

DTGA: limited mixing of pulmonary venous blood into systemic circulation causes cyanosis





Premature closure of PFO

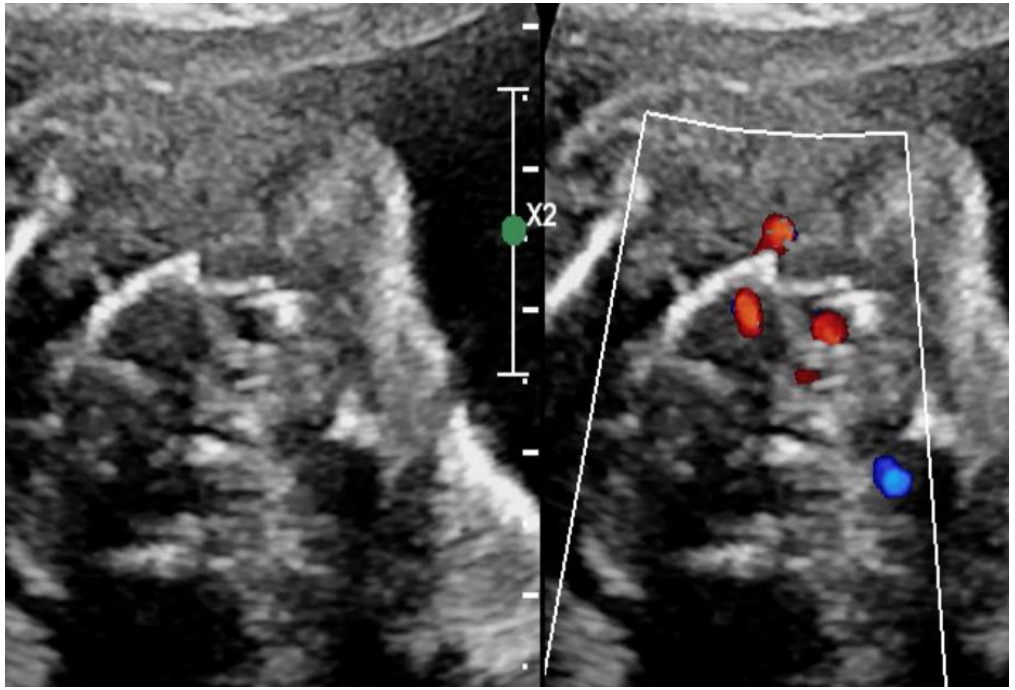
-Right heart failure

-Hydrops

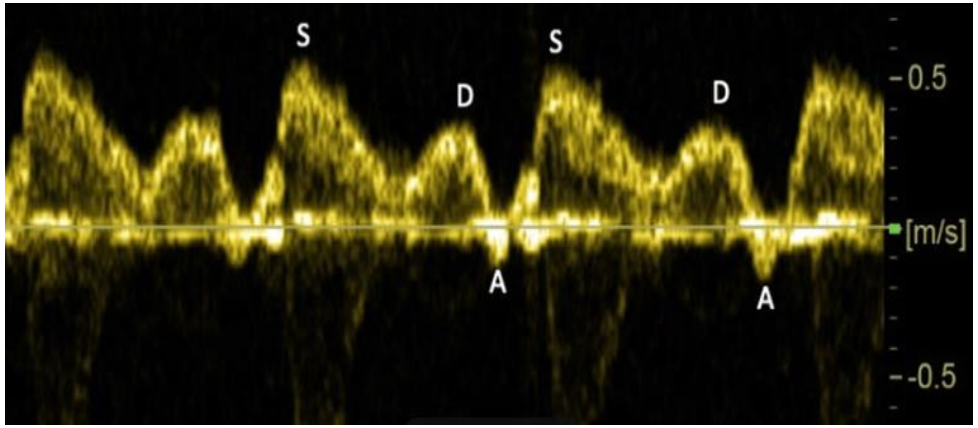
-Arrhythmia

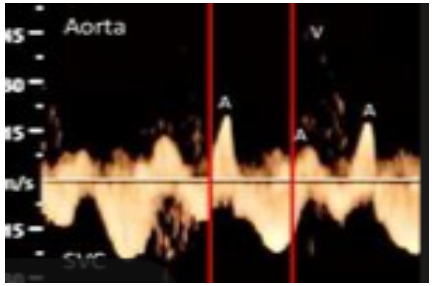
-Development of HLH?

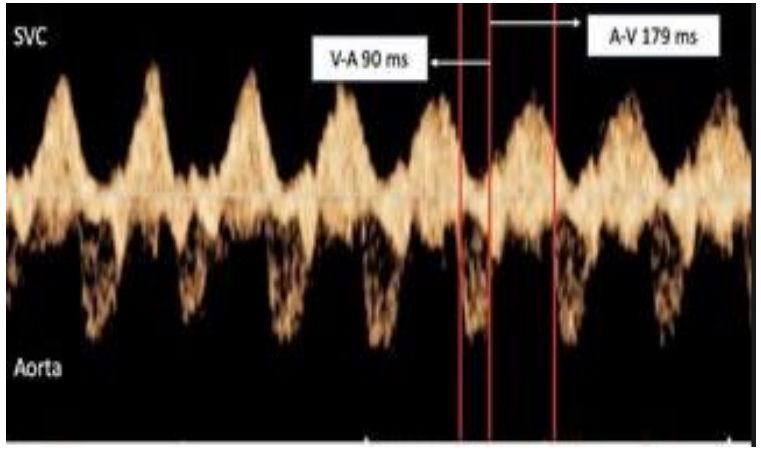
SVC/LSVC



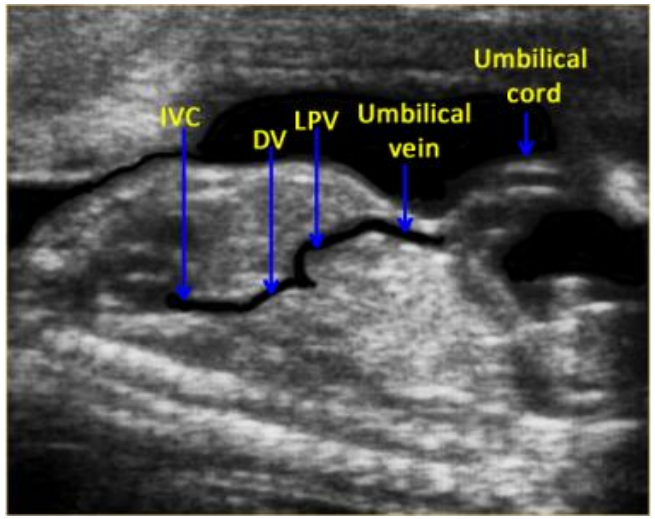
SVC : Abnormal

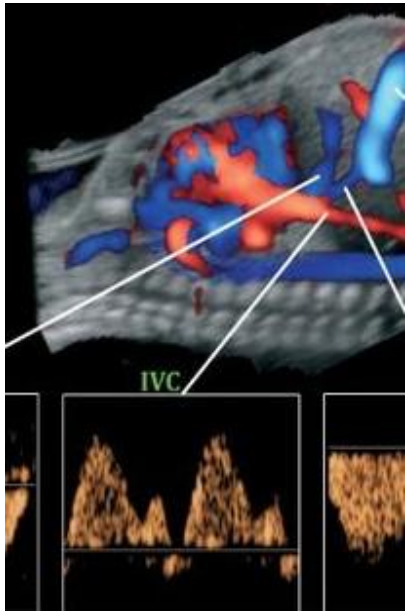


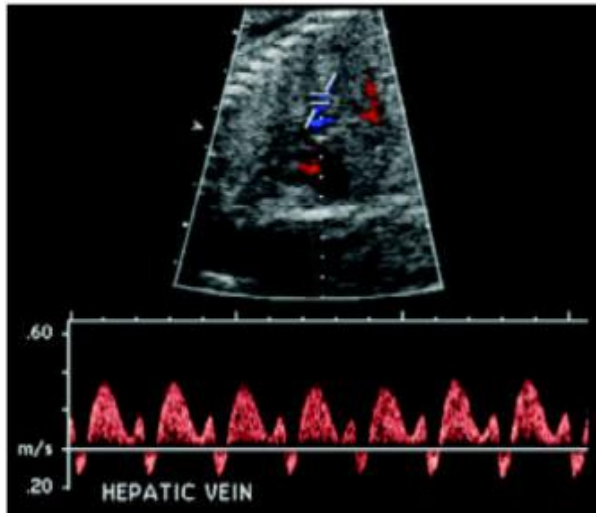




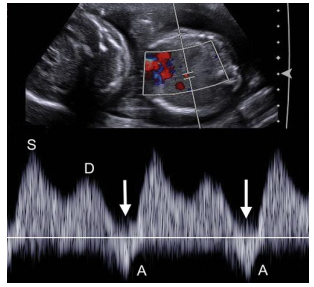
Hepatic and IVC Doppler





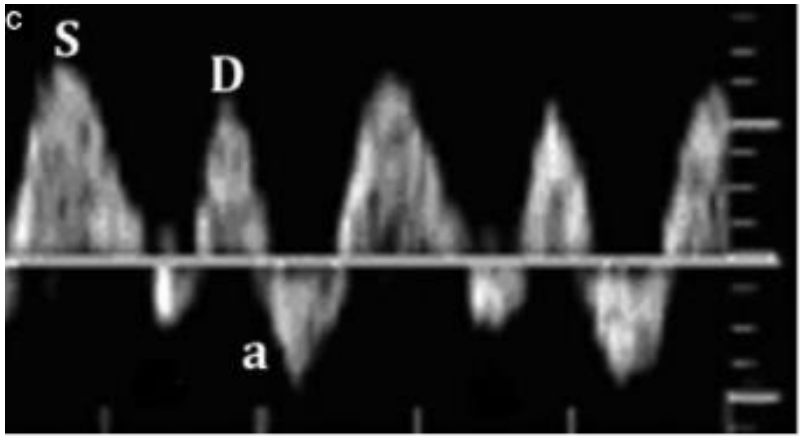


Abnormal IVC/Hepatic Vein flow



Normal

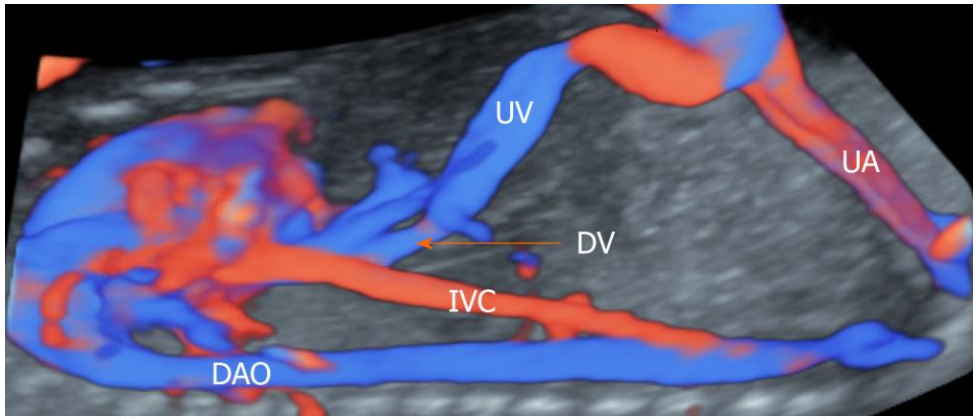
ABNORMAL

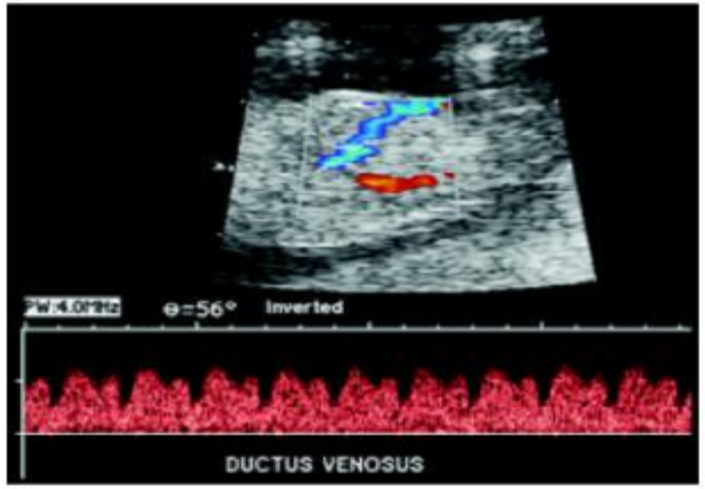


Causes:

IUGR
Hydrops
Tricuspid Atresia
Severe TR
Ebstein's/TV Dysplasia
HRH

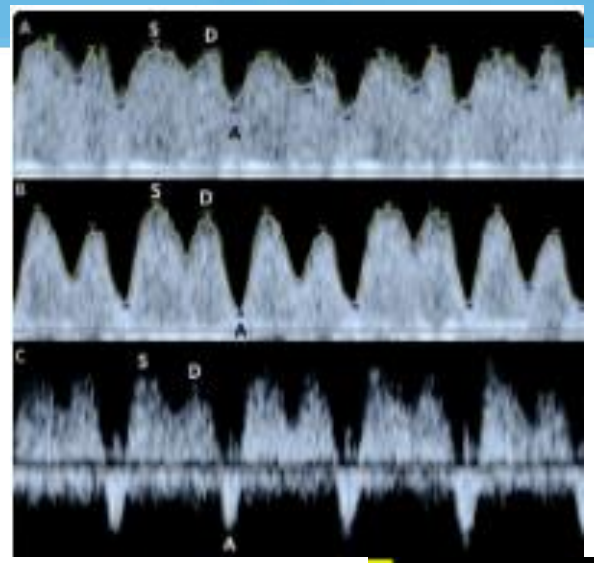
Ductus Venosus Doppler





- Best obtained in sagittal view
- Phasic antegrade, forward flow
- (may have reversal prior to 17 weeks)
- Resembles an “M” pattern, S wave, E wave, A wave
- S-ventricular systole
- E-early diastole (some D wave)
- A- decrease in flow, atrial contraction (may show reversal)

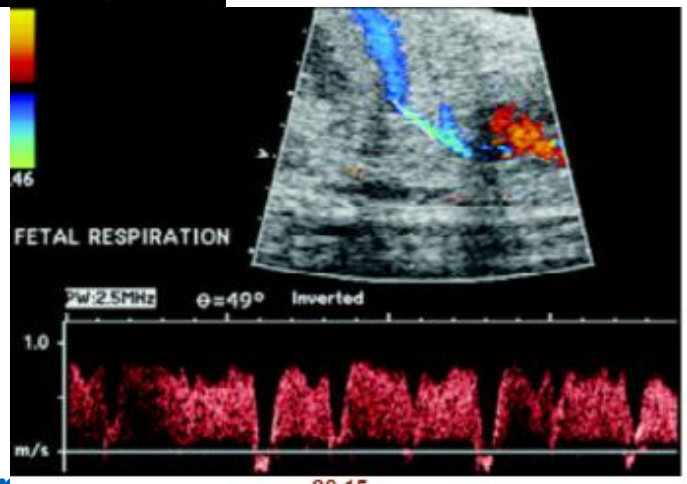
Abnormal Ductus Venosus



Normal

Decreased velocity

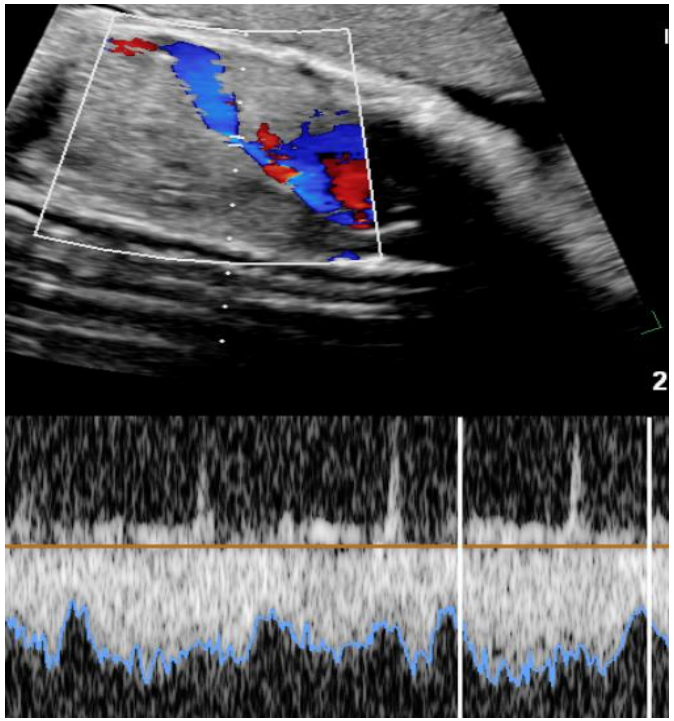
A wave reversal

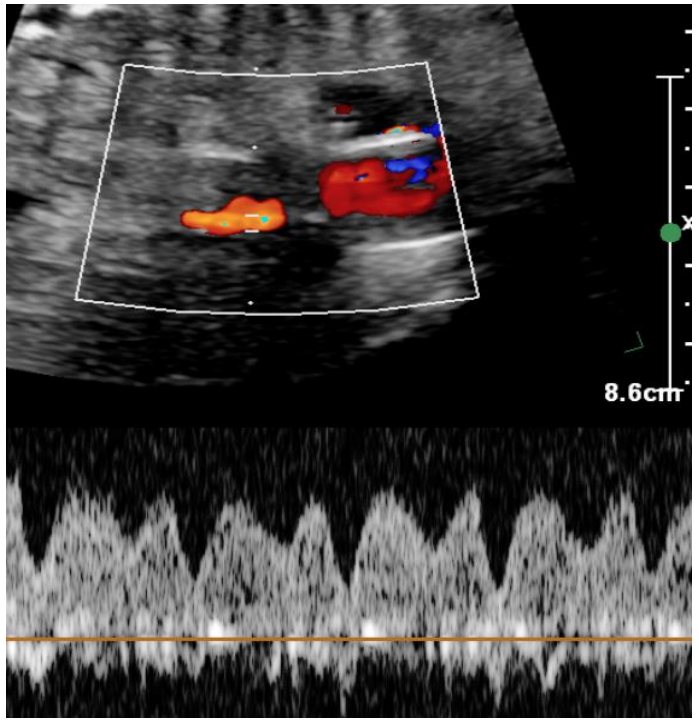


2D image: sagittal plane but focusing on the upper abdomen

CFM box: broad to include hepatic vessels, IVC and track intra abdominal UV course
Gate: narrow, small
Scale: set for venous flow (30-60cm/sec)

Ductus Venosus HLHS & Aortic Stenosis





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Umbilical Cord: UV/UA

Two arteries and one vein (Normal)

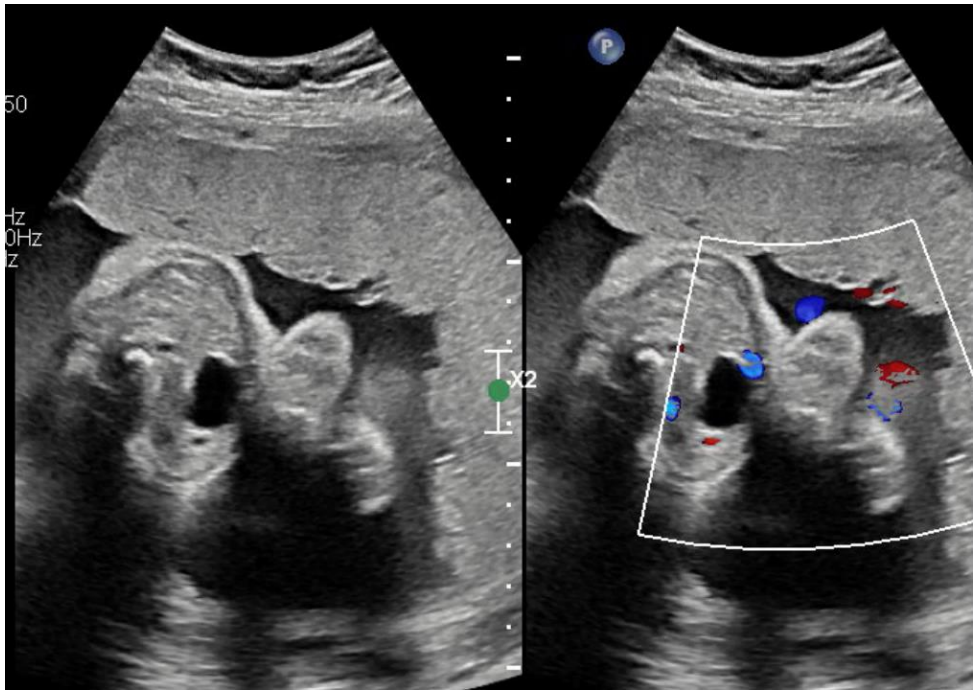
Sample from free area midway between the fetus and placenta –long segment of free-floating cord.

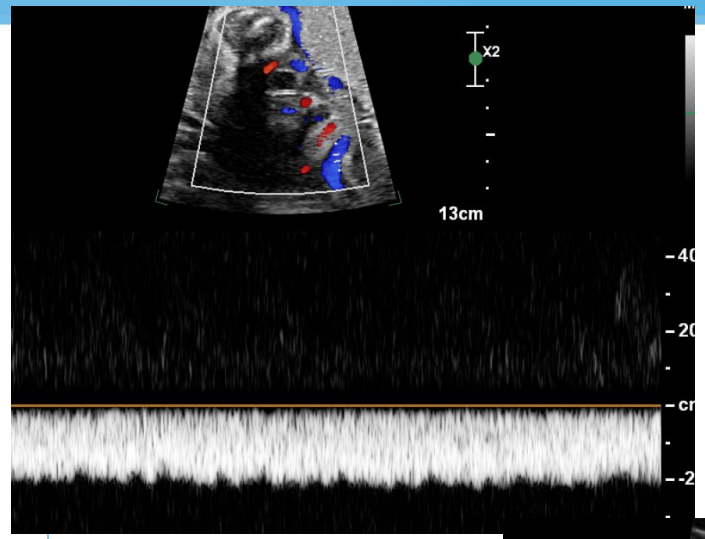
UA/UV at same time preferred to see, but can be separate (medium gate)

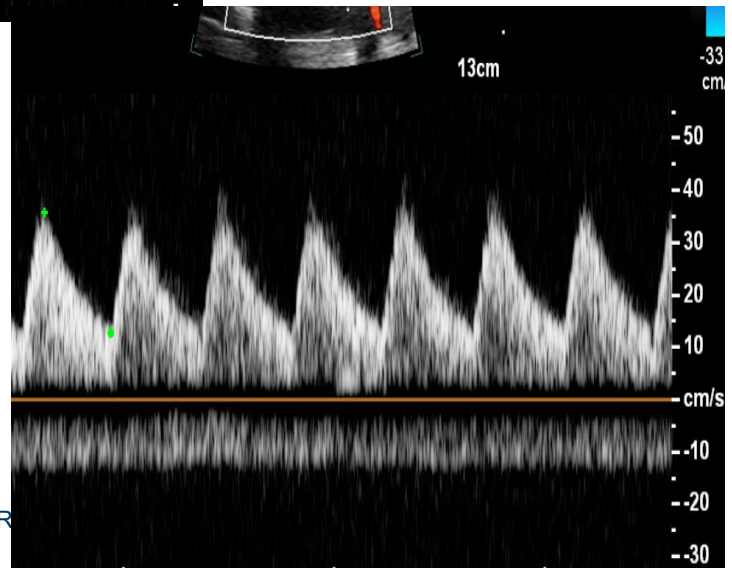
UV is normally continuous, low-velocity flow

UA has a systolic and diastolic component representing the velocity of flow through the artery

Umbilical Cord Doppler







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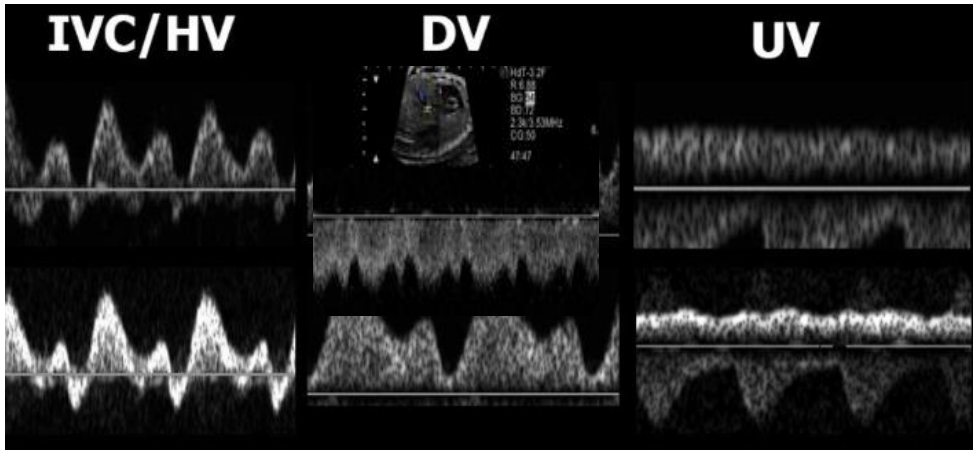
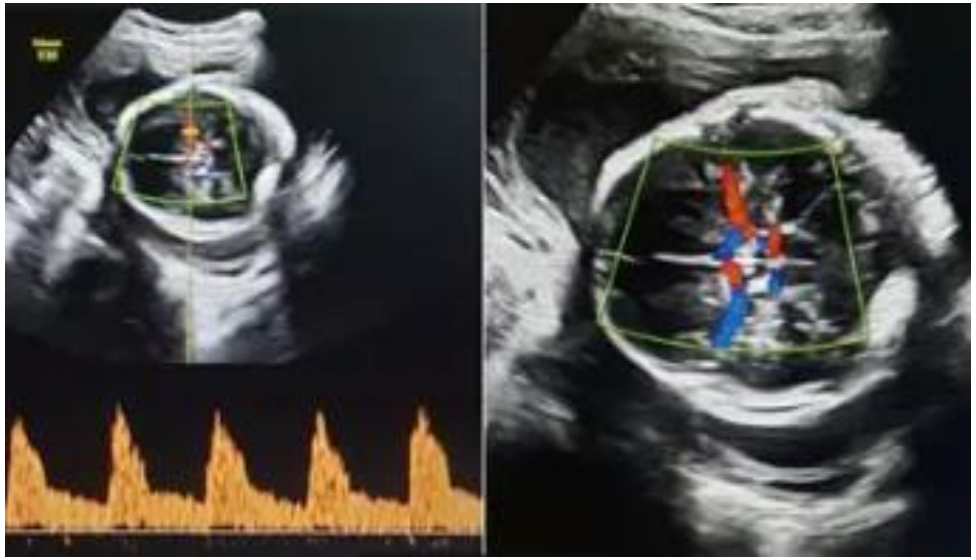
PLACE INSTITUTE, DIVISION, DEPARTMENT, OR

IVC/DV/UV patterns:



Middle Cerebral Artery



Color scale lower

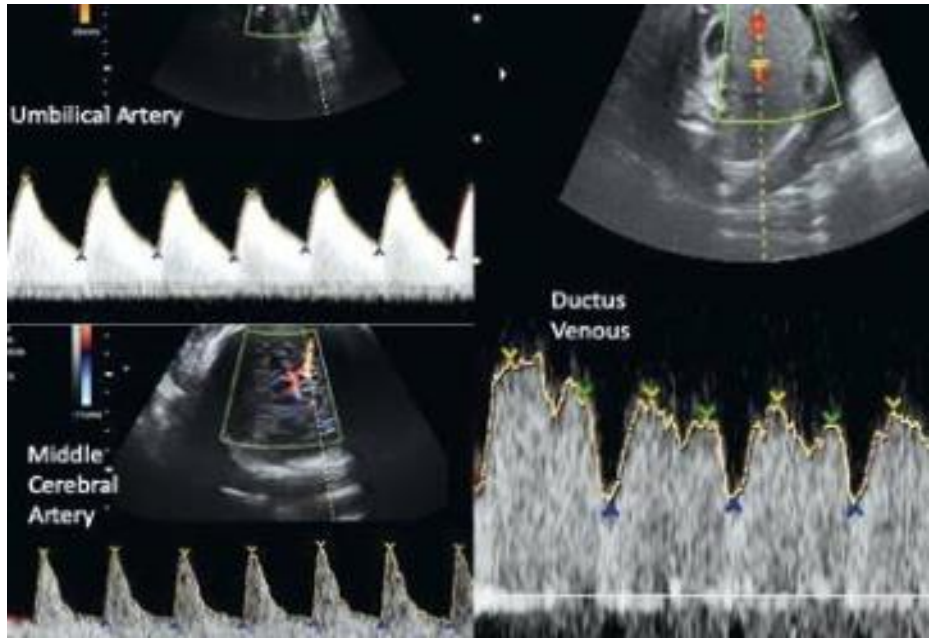
Sample volume midway

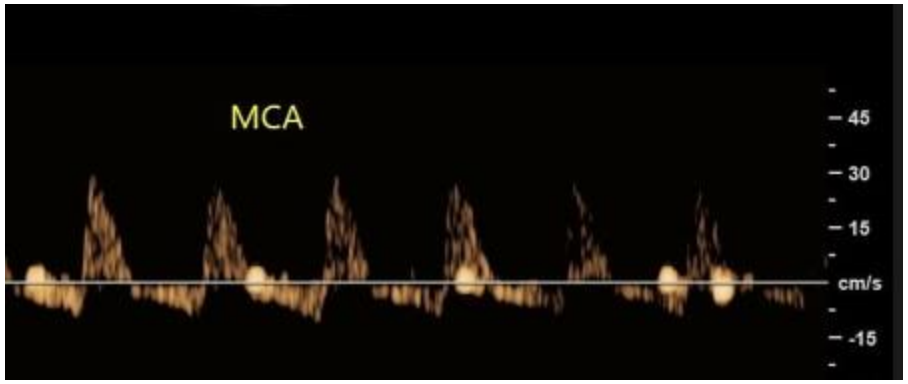
Use gate 2-3cm

Optimize Spectral Doppler scale

PSV increases from 24cm/sec-59cm/sec with further gestation

Middle Cerebral Artery





Tips for acquisition

- Place sample volume distal to targeted valves or within the vessel (veins/artery)
- Keep interrogation angle at less than 30 degrees from direction of blood flow
- Place sample volume at brightest colors of blood flow segment
- Obtain Doppler waveforms during fetal apnea (and sometimes maternal breath holds)
- Obtain multiple measurements (especially if the angle lines up, take advantage)

Links:

Fetal Combined Cardiac Output Calculator | fetal.parameterz.com

Fetal Cardiology Educational Series - Archives - Children's Mercy
Continuing Medical Education - Continuing Education (CE) - Fetal Cardiology Educational Series - Archives

Resources:

(PDF) Doppler study of fetal venous system

Maso, Gianpaolo & G, Conoscenti & Piccoli, Monica. (2008). Doppler study of fetal venous system.

Mielke G, Benda N. Cardiac output and central distribution of blood flow in the human fetus. Circulation. 2001;103(12):1662–8. Values at 34 weeks corroborated by Mao et al. (n=506): LV 391 ml/min, RV 573 ml/min, CCO 964 ml/min.

Predictive Value of Fetal Pulmonary Venous Flow Patterns in Identifying the Need for Atrial Septoplasty in the Newborn With Hypoplastic Left Ventricle

Guidelines and Recommendations for Performance of the Fetal Echocardiogram: An Update from the American Society of Echocardiography

Fetal cardiovascular imaging
a disease based approach
by Jack Rychik and Zhiyun Tian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